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ABSTRACT

This document provides descriptions of lessons, activities, and laboratory experiments to be used in a course on basic laboratory techniques for students in biology and small animal care. These learning experiences are designed to be completed during one class period daily for approximately 70 days per semester. (It is assumed that this would leave sufficient time for laboratory quizzes, practical examinations, formal tests, use of multimedia materials, and review.) The aim of the course is to integrate the recitation and laboratory lessons so that they are mutually supportive. Each lesson is divided into six parts. These include: (1) the aim of the lesson; (2) the materials needed; (3) the learning outcomes expected from the lesson; (4) motivational suggestions; (5) the actual lesson procedures; and (6) some summary questions. The lessons (46 in all) are divided into sections on basic laboratory procedures, hematology, and urinalysis. A list of selected reference materials is also provided. (TW)

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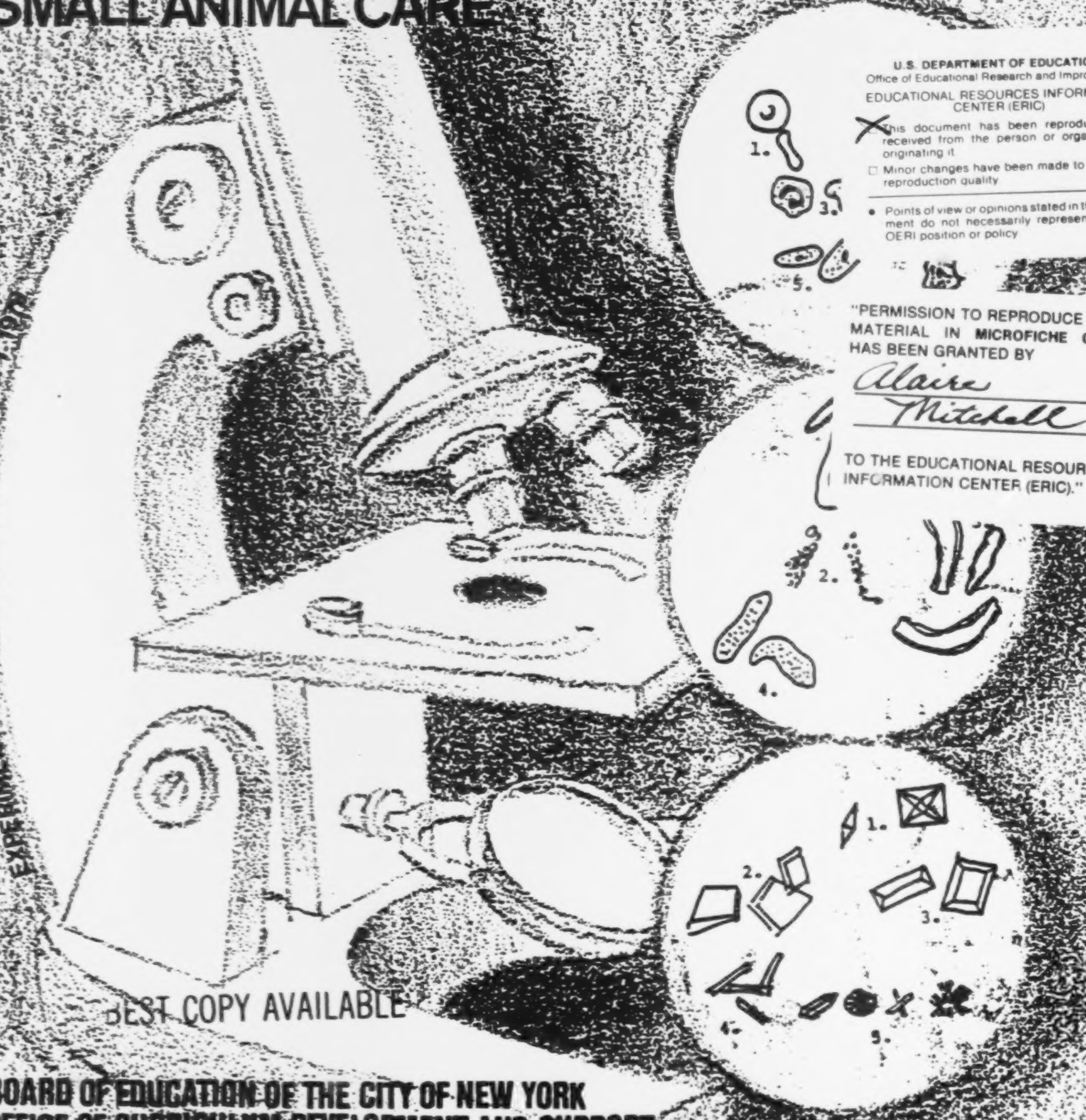
BASIC LABORATORY TECHNIQUES

FOR STUDENTS OF BIOLOGY AND SMALL ANIMAL CARE



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The project was supervised by Sam Fried, then assistant director of science, Center for Mathematics and Science.

The original manuscript was prepared by Jerome Schoen and Paul Berman, teachers at John Bowne High School, Queens, New York.

Leonard Bernstein, science teacher at the Arthur Schomburg Intermediate School 201, edited and prepared the manuscript for distribution.

Joseph Feld prepared the cover design and Conrad Nunnally executed the text art; both are members of the staff of the Office of Curriculum Development and Support.

INTRODUCTORY REMARKS TO THE TEACHER

Why should you offer students a course in basic laboratory techniques such as is described here?

First of all, the course provides a truly enjoyable learning experience--in a word, it can be fun!

Secondly, the course provides an excellent opportunity for students to discover their own inclinations and abilities -- a big step toward making career decisions.

Thirdly, basic laboratory techniques as a course offers the teacher more than the usual gratification as he/she opens doors of discovery and professional possibilities to young students.

The lessons in Basic Laboratory Techniques for Students of Biology and Small Animal Care are designed to be given one period daily for about 70 days per term. This allows time for laboratory quizzes, practical examinations, formal tests, use of multimedia materials, and review. It provides for a wide variety of recitation classes as well as many laboratory sessions. The aim of the course is to integrate the recitation and laboratory lessons so thoroughly that they are mutually supportive.

Each lesson is divided into the following parts:

- aim
- materials
- outcomes
- motivation (suggested only!)
- procedures
- summary questions

How the actual lesson develops is, of course, the province of the individual teacher.

Students come with different capacities and aspirations. This course is elastic enough to provide for a wide range of differences. Not only is it useful for students of biology and small animal care, but also for some general science students. It aims to offer a challenge that will help students prepare for many different kinds of entry-level occupations. The development of manipulative skills, so necessary in many occupations, is emphasized through "hands-on" experiences.

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UNIT I

BASIC LABORATORY PROCEDURES

INTRODUCTION

An understanding of laboratory safety and techniques is essential for students of biology and small animal care. To derive any benefit from a laboratory course, the student must possess or develop attitudes, organization, and skills which will allow him or her to function in a laboratory setting. Unit I is designed specifically to strengthen the student's capacities in exactly these areas. It attempts to motivate the student in terms of vocational goals, and it offers both the structure and skills needed in basic techniques to encourage the student to feel confident and successful in the laboratory setting. So that a continuity may be established between the work of this Unit and those to be studied later, the student actually prepares some simple laboratory equipment to be used in later exercises. Also, students apply techniques and understandings from Unit I in later work. An example of this is the utilization of pH determination in urinalysis.

Lesson 1 Career Opportunities

Aim: How can this course help me to choose my career?

Materials

student career sheet (for class distribution)

Outcomes

Students become aware of career possibilities
Students become aware of course scope
Students become aware of course benefits to them

Motivation

Ask the class how many among them have pets, and further, from whom they were purchased, to whom they take them for illness, or perhaps, board them. Ask what qualifications these people must have to do their jobs properly.

Procedures

1. Elicit from class how many among them may be pet owners, and their dependence, usually upon trained or knowledgeable specialists, to take care of their pets' needs (for grooming or illness).

2. Draw from the class a list of careers in which the care of small animals is involved, and what may be the level of training needed to function in these careers. Add to the list of careers and the training required for each.

3. Distribute the student career list. Review each of the careers listed and the qualifications for each.

4. Discuss the organization and subject matter of the course. Ask students how they think they might apply the course subject matter to their own choice of career.

Summary Questions

1. What training is necessary for the people who help you take care of your pets?
2. What are some careers that are related to the welfare of small animals?
3. How can this course help you choose a career in small animal care?

Optional Activities

1. Have a student present an oral report describing a visit to the office of a veterinarian, work the student has done in a pet shop, or similar personal experiences.

2. Invite a guest speaker from one or more of the listed career areas to address the class regarding the nature of his or her work. This might be an appropriate time for a general discussion of career opportunities.
3. Encourage students to select career areas of their own interest, and prepare detailed written descriptions of the work they involve as well as the preparation necessary for them. These might be posted on the class bulletin board.
4. Have students write to the United States Department of Agriculture for publications in small animal care, for possible use in class.

Lesson 1

Career Opportunities

STUDENT CAREER SHEET

Name ______________________________ Date ____________ Section _______

Entry-Level Careers

- Animal Caretaker
- Veterinary Assistant
- Zoo Keeper
- Dog Groomer
- Fur Farmer
- Kennel Person
- Animal Breeder
- Pet Shop Clerk
- Exterminator
- Dog Warden
- Dog Trainer
- Wildlife Aide and Gamekeeper
- Taxidermist Assistant
- Animal Laboratory Assistant

Technical Careers

- Animal Laboratory Technician
- Veterinary Laboratory Technician
- Civil Service Careers
- Marine Life Technologist

Professional Careers

- Marine Biologist
- Ecologist
- Zoologist
- Refuge Manager
- Entomologist
- Wildlife Biologist
- Teacher of Agricultural Subjects
- Veterinarian

Lesson 2 Laboratory Safety

Aim: What are some potential dangers in the science laboratory?

Materials

concentrated sulfuric acid
glass rod
acid-damaged fabric
hydrochloric acid
frayed electric cord
Bunsen burner
safety matches
safety goggles
scalpel
50 ml beaker
typing paper
nitric acid
sodium hydroxide
sealed petri dish with bacterial culture (if available)
glass tubing
250 ml beaker
student worksheet (for distribution)

Outcomes

That students recognize these general areas of potential danger in the laboratory:

a. Extreme heat (fire, hot substances)
b. Chemicals (poisonous, corrosive)
c. Gases (flammable, explosive, toxic)
d. Glassware (potential for inflicting wounds)
e. Microorganisms (potential for infection)
f. Sharp or pointed instruments (potential for wounds and infection)
g. Electrical apparatus (danger of shock and fires)

Motivation

Place a small amount of concentrated sulfuric acid into a 50 ml beaker. Use a glass rod to place several drops of the acid onto a piece of typing paper. Have the students note what occurs. Display a piece of acid-damaged or other similarly affected material. Elicit the appearance. Tell the students that they will be working with acids and other corrosive liquids during the course of the program. Have them suggest some of the dangers involved in working with these substances.

Procedures

1. Display labelled bottles of HNO_3, HCl, and NaOH. Explain that these are also corrosive chemicals (especially to human tissues).

2. Show a length of frayed electric cord. Ask students if they would use such a cord on a lamp in their own house. Develop an awareness of the hazards of shock and fire that may accompany the use of faulty electrical equipment.

3. If available, display a sealed petri dish containing a flourishing bacterial culture. Elicit the importance for keeping the dish sealed. Guide students to the understanding that some microorganisms are dangerous agents of infection and disease.

4. Heat a piece of glass tubing over the bunsen burner flame. Display the piece of tubing and stress the fact that although it is hot, its temperature cannot be determined by sight alone. Plunge the hot end of the tubing into a beaker of cold water. Have the students note what happens (steam, hissing, possible fracturing of glass). Elicit that heat and spattering of hot liquids are a source of potential danger in the laboratory.

5. Hold up a scalpel. Have the students identify it and its use in biology. Establish the potential for wounds from this and any other cutting or piercing object, including broken laboratory glassware.

6. Distribute and have the students complete the chart listing potential dangers in the science laboratory.

7. Distribute the list of safety precautions to be followed in the laboratory. Review each of the items and emphasize the importance of each in the prevention of accidents in the science laboratory.

Summary Questions

1. Why are goggles necessary for certain laboratory procedures?
2. Suppose that the Bunsen burner flame was blown out, but the gas remained turned on. What might happen to a laboratory animal left over night? What might happen in the laboratory if some one lit a match the next day?

Optional Activities

1. Have one or more students report on the possible dangers involved in the use of X-rays on small laboratory animals.
2. Why do veterinarians wear rubber gloves while performing operations on laboratory animals?

Lesson 2 Laboratory Safety

Student Laboratory Sheet

Name ______________________ Date ________ Section ________

Potential Dangers in the Science Laboratory

Source	Possible Injury
Heat: fire, hot liquids, gases (steam), solids	
Chemicals: corrosive (such as acids and bases), or toxic	
Poorly insulated or misused electrical apparatus	
Disease-causing organisms; such as bacteria, fungi, worms	
Sharp or piercing objects, such as scalpels, needles, broken glass	
Gases: illuminating gas, vapors (ether, chloroform)	

Lesson 2 Laboratory Safety

STUDENT SAFETY PRECAUTIONS

1. Never enter or try to work in the laboratory if a teacher is not present.
2. Never handle equipment or chemicals without the instructions and consent of the teacher.
3. Never taste or drink chemicals or other unknown materials.
4. Never pour used chemicals back into their original stock bottle containers.
5. Never work with sharp tools or glassware unless you have been instructed how to do so.
6. Never use unprotected hands to pick up metals or glassware that may be hot. Use tongs or a holder as necessary.
7. Always know beforehand what is expected of you in the laboratory. Prepare in advance.
8. Always report damage to apparatus to the teacher immediately.
9. Always report personal injury to the teacher immediately, even if seemingly unimportant.
10. Always turn off burners when not in use.
11. Always wash hands with soap before and after working with bacteria.
12. Always report spills of bacterial cultures to the teacher immediately.
13. Always pour bacterial cultures into the container provided and not into the sink.
14. Always point the mouth of a test tube being heated away from yourself and your classmates.
15. Always wear clothing in the laboratory that is least likely to get caught in apparatus, or to catch fire.
16. Always wear your hair in such a way as to avoid its likelihood of catching fire.
17. Always dispose of broken glassware in the containers provided.
18. Always keep the laboratory sink clear of trash.
19. Always wear protective goggles when heating liquids or otherwise handling substances which may bubble upwards or spatter suddenly.
20. Always be serious in the laboratory. The laboratory is never a place to play.

Lesson 3 Animals As Living Things

Aim: What must we know about animals to care about them properly?

Materials

variety of caged animals (hamster, gerbil, mouse, cat, guinea pig, rabbit, bird, etc.) and aquaria
preserved specimens of several invertebrates: earthworm, grasshopper, clam, jellyfish, etc.

Outcomes

Animals share certain characteristics which set them apart from other living things.
There are five main groups of vertebrates; each with its own special needs for survival.
Animals are complex living things with organs and organ systems that perform special functions.

Motivation

Display the specimens available. Ask the students to suggest why these living things are classified as animals.

Procedures

1. Ask students for examples of animals. Ask whether an earthworm or a grasshopper or a bird or snake are animals. Discuss the characteristics shared by all animals. They are all:
    a. many-celled
    b. unable to manufacture their own food (heterotrophic) as plants do, and must therefore eat the meat of other animals or the tissues of plants or other living things
    c. able to move body parts by means of contracting fibers such as those which make up muscles

   Refer to the animals on display and show how these all satisfy the definition of animal given above.

2. Discuss the characteristics of vertebrates:
    a. spinal column
    b. skull
    c. ribs (usually)
    d. paired appendages (legs, fins, wings, etc.)

3. Develop the understanding that scientists divide the vertebrates into five major groups. Establish that each of these groups is distinguished from another by the presence of certain characteristics. For example:

-fishes: breathe through gills, many have scales
-amphibians: possess gills during the early stages of their development, and lungs as adults
-reptiles: have scaly skin, lungs, toes with claws
-birds: possess beaks, feathers
-mammals: have fur, hair or bristle, feed milk to their young

Elicit examples from each group.
fishes: cod, goldfish, perch, shark
amphibians: frog, toad, salamander
reptiles: snakes, lizards, turtles
birds: robin, hawk, owl, ostrich
mammals: whale, human being

4. Elicit from the class that all of these animals are alive and well as a result of the combined activities of their various organs and organ systems.

Place the following on the board. Have the students complete the table by suggesting the function of each organ system given.

FUNCTIONS OF ORGAN SYSTEMS

Organ System	
Digestive	
Circulatory	
Respiratory	
Excretory	
Nervous	

Summary Questions

1. Why do we call certain living things animals?
2. What characteristics make an animal a vertebrate?
3. What are the different vertebrate groups?
4. How do the systems of all of these types of animals enable them to carry out the functions that keep them alive?

Optional Activities

1. Visit a museum or nature center. Have students report on the different groups of animals exhibited.
2. Discuss the current system of classification. Challenge students to design their own classification system. What criteria might they use?

Lesson 4 Humane Treatment of Laboratory Animals

Aim: How do we keep animals healthy in the laboratory?

Materials

variety of caged animals (hamster, gerbil, mouse, cat, guinea pig, rabbit, bird, etc.), and aquaria

Outcomes

Animals can maintain life, grow, and reproduce only when certain environmental conditions are provided.
Proper animal care is achieved by well-trained personnel.

Motivation

Display the specimens available. Encourage students to observe each of the animals and their immediate environment. Draw attention to food and water provisions. How are temperature needs met? Elicit the types of activity in which individual animals are engaged.

Procedures

1. Call attention to the apparent good health of tha animals exhibited. Personalize by asking students how they might take care of such animals or their own pets to keep them in good health.

   Elicit the need for proper shelter, nutrition, clean water, suitable temperature, ventilation, proper handling, and sanitation. Recall the previous study of the organ systems and their functions. Point out that certain conditions are necessary for good health to be maintained.

2. On the board, develop the following table of basic animal needs.

NEED	HOW PROVIDED FOR
suitable housing	spacious and securely locked cages
proper nutrition	commercially prepared food designed for each species
clean water	water supply changed daily, special water bottles provided in most cages
proper temperature	room housing cages is temperature controlled
good ventilation	air maintained at higher pressure, incoming air filtered
expert handling	personnel trained for handling each species
sanitary conditions	cages cleaned daily

3. Have students compare the needs of the different species in terms of nutrition, handling, sanitation, etc. Have them conclude from their own answers how much there is to know about small animal care. Establish the need for highly trained personnel.

   Some sample comparisons the teacher can lead students to make might include the following:

   - Hamsters, gerbils, and guinea pigs are herbivores for whom commercially prepared foods are available. These include supplementary vitamins and are compounded with extra roughage for older animals. All like fresh greens.

   - Dogs and cats are carnivores. A high protein diet (meat and fish) is preferred, including small amounts of plant material. Commercial foods are available.

   - No unfamiliar animal should be handled unless hands are heavily protected in horsehide or buckskin gloves. Movements of the hands should never be sudden, and attempts to pick up animals while they are feeding should not be made. Once an animal has been picked up, it should be supported by a hand beneath it and not be permitted to dangle uncomfortably or painfully.

   - Indicate that later lessons on the diseases found in small animals will demonstrate the importance of nutrition and sanitation provided for all species.

4. Elicit those attributes necessary for working with small animals: compassion, hard work, and an understanding of the needs and habits of small animals.

Summary Questions

1. What conditions would have to be provided to keep small laboratory animals healthy?
2. What qualifies a person for caring for small animals?

Lesson 5 The Metric System: Linear Measurement

Laboratory Exercise

Aim: How do we use the metric system to measure length?

Materials

yardstick and ruler (both with metric and English scales); chart on origin of English units of measurement; chart on metric units of length

Outcomes

The metric system is the system used for most scientific measurement.

The metric system is a decimal system in which the units are related to each other as multiples of ten.

Length, volume, and mass can all be measured using the metric system.

The units of length, volume, and mass are all related.

In the metric system, the basic unit of length is the meter (defined as a multiple of a wavelength of light given off by krypton-86).

Motivation

Scientists claim that the English system of measurement has many disadvantages, yet it is still widely used in this country. Challenge students to explain why this is so.

Procedures

1. Develop the following table to illustrate that fundamental units of length in the metric system can be derived from one another by multiplication or division.

METRIC UNIT	SYMBOL	AMOUNT	NUMBER VALUE
meter	m	one	1
kilometer	km	1 thousand	1,000
centimeter	cm	1 hundredth	.01
millimeter	mm	1 thousandth	.001
micrometer	µm	1 millionth	.000001
nanometer	nm	1 billionth	.000000001

Inform students that the micrometer (µm) was formerly known as the micron (µ).

2. With the aid of a metric chart, elicit the relationships between meters, centimeters, and millimeters. (Hint: Ask students to count the number of millimeters per centimeter on the chart, and to define "centi" and "milli.")

3. Demonstrate to the students the advantage of simply moving decimal points to measure in different units of the metric system. (Movement to the left is multiplying, to the right, dividing.)

4. Distribute student laboratory sheet and encourage students to complete these. Circulate among the students giving assistance as required.

Summary Questions

1. What is the relationship between the millimeter and the centimeter?
2. Which metric unit would be most useful for measuring cells? Explain your answer.
3. How many micrometers are there in one millimeter?

Optional Activies

1. Convert the speed of light (186,000 mps) into metric units.
2. What evidence is there that the United States is attempting to convert to metric system measurements in length?

Lesson 5 The Metric System: Linear Measurement

Student Laboratory Worksheet

Name ______________________ Date ____________ Section _________

Aim: How do we use the metric system to measure length?

Materials

yardstick and ruler (both with metric and English scales)

Procedures

1. Examine the yardstick and ruler. How are these measuring devices alike? How are they different?
2. Using your metric ruler, draw pencil lines of the following lengths.
    a. 50 millimeters
    b. 10 centimeters
    c. 25 millimeters
    d. .25 centimeters

   Which of the above lines are identical in length? What relationships exist between the millimeter and centimeter?
3. Perform the following conversions:

    a. 1 m = 100 cm = ________ mm

    b. 0.5 m = 50 cm = ________ mm

    c. 2.5 m = 250 cm = ________ mm

    d. .25 m = 25 cm = ________ mm

    e. .13 m = 13 cm = ________ mm

    f. .05 m = 50 cm = ________ mm

Lesson 6 The Metric System: Volume Measurement

Laboratory Exercise

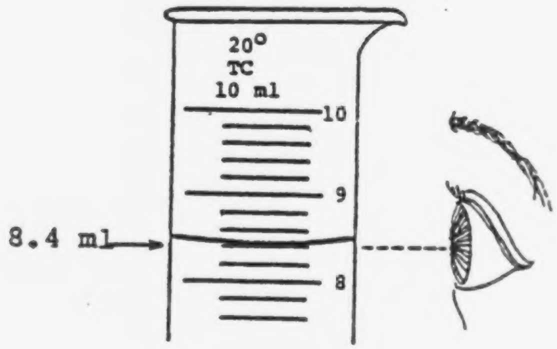
Aim: How may the metric system be used to measure volume?

Materials

- 1,000 ml graduate cylinder
- small, irregularly shaped object
- cubes of Fe, Mg, Cu, Al (each of equal dimension)
- string
- metric ruler
- 1 liter lucite container
- student laboratory worksheet (for distribution)

Outcomes

Volume is the amount of space occupied by a substance.
A liter is the basic unit of liquid measure.
The volume of solids may be expressed in cubic centimeters (cc) or cubic meters.
The volume of a liquid contained in graduated glassware is read from the meniscus (the upper, curved surface of the liquid).
The meniscus rule states that volume is determined from the volume line on which the bottom of the meniscus rests.



Procedures

1. Display the lucite container and the 1,000 ml graduated cylinder. Elicit differences in size and shape.

2. Ask for a student volunteer to determine the volume of the lucite container.

3. Have a student read the volume of the graduated cylinder. Elicit that the volume of both containers is the same. Confirm this by filling the graduated cylinder to the 1,000 ml mark and transferring the contents of the cylinder to the lucite container.

4. Develop the concept that the liter is the basic unit of liquid measure in the metric system. (Have students recall that the liter is equal to 1,000 ml.)

5. Refer to the lucite cube. Establish the fact that its volume equals 1,000 cc. Tell students that scientists use both cubic centimeter (cc) and milliliter (ml). Explain that 1,000 cc is expressed as 1,000 ml when liquids are measured.

6. Fill the graduated cylinder with water to the 500 ml mark. Using a piece of string, lower the iron cube into the cylinder so that it is completely immersed. Have a student volunteer read the new level of the water. Challenge the students to determine the volume of the iron cube.

7. Repeat the above procedures using the remaining cubes. Have students determine the volume for each cube through direct measurement, and through water displacement. Reinforce the concept that volume in milliliters and cubic centimeters is the same.

Summary Questions

1. What relationships exist between a liter, a volume of 1,000 cubic centimeters, and 1,000 milliliters?
2. How do you know when to use the term cubic centimeter or milliliter?
3. How many 10-centimeter cubes would it take to fill a container whose dimensions are 10 cm x 10 cm x 10 cm?

Lesson 6 The Metric System: Volume Measurement

Student Laboratory Worksheet

Name ______________________ Date __________ Section ________

Aim: How may the metric system be used to measure volume?

Materials

cubes of Fe, Mg, Al, and Cu (each of equal dimension); string; small, irregularly shaped object; 1,000 ml graduated cylinder; metric ruler; 100 ml graduated cylinder

Procedures

1. Use the 100 ml graduated cylinder. Carefully study the line markings.

2. You will use water to help you practice reading the level of the meniscus. Fill the cylinder using the volumes given below. After each filling, check with your teacher.
    Filling 1. 25 ml
    Filling 2 53 ml
    Filling 3. 70 ml
    Filling 4. 84 ml
    Filling 5. 98 ml

3. You learned how to find the volume of a regularly shaped object. Using your metric ruler, try to determine the volume of a small, irregularly shaped object. What do you notice?

    ____

    ____

4. From what you have learned, describe briefly how you might determine its volume. Present your plan to the teacher before you proceed. Include the materials you will need.

    Plan: ____

    ____

    ____

    ____

5. Determine the volume of the object. Have your teacher check your results.

Summary Questions

1. State the meniscus rule.
2. How can you determine the volume of an irregularly shaped object?
3. How many milliliters of water would be taken up (displaced) by a cube whose dimensions are 2 cm x 2 cm x 2 cm?
4. Define: volume, displacement.

Lesson 7 Laboratory Pipettes

Aim: How are pipettes used in the laboratory?

Materials

measuring pipette, transfer pipette, selection of other types of pipettes for demonstration, 50 ml beaker

Outcomes

A pipette works on the same principle as that of a drinking straw. When the air pressure on the liquid contained within the tube is decreased, the liquid rises because outside air pressure forces the liquid up in the tube.

Measuring pipettes are graduated, with a scale showing the volume of liquid taken in or delivered.

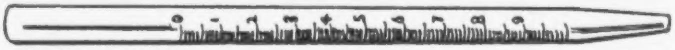
Transfer pipettes may have an enlarged section, and each delivers only a certain, fixed volume

Motivation

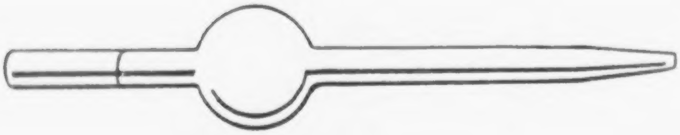
Display a 50 ml beaker containing water colored with a vegetable dye. Ask students to suggest how they might remove small volumes of liquid (2.4 ml or 5 ml) from the beaker.

Procedures

1. Display the measuring pipette. Point out the calibrations. Show the transfer pipette. Emphasize its usefulness for the transfer of fixed volumes.



Measuring Pipette



Transfer Pipette

2. Review the meniscus rule. Guide students to the understanding that volume is determined from the volume line on which the bottom of the meniscus rests.

3. Demonstrate the filling of a pipette; drawing the solution beyond the required mark, placement of the index finger over the upper tube opening, wiping the tip, slow discharge of any extra liquid until the meniscus reaches the desired level, and final wiping of the tip.

4. Demonstrate the discharge of liquid from a pipette: control liquid flow by index finger pressure at upper end; necessity for controlled (slow) flow to keep from leaving liquid behind in the pipette barrel.

5. Demonstrate the technique for discharging liquid from a small pipette: touching the tip of the pipette to the side of the container receiving the liquid for several seconds, then blowing out the remaining drop.

6. Demonstrate or discuss other types of pipettes (dropping or red cell counting types) as may be available.

7. Encourage students to examine the graduations on various pipettes. Have them prepare drawings and practice filling and emptying them.

Key Questions

1. Which pipette would we use to transfer 2.4 ml of solution? 5 ml of solution?
2. Why is the meniscus rule necessary?
3. Why must the last drop of liquid be blown out of some pipettes but not others?

Lesson 8 The Metric System: Weight Measurement

Aim: How is the metric system used to measure weight?

Materials

double-pan balance, triple-beam balance, variety of objects for weighing, assorted metric weights, pencil, paper

Outcomes

The gram is the basic unit of weight in the metric system.
In the metric system, large units of weight are measured in kilograms.
The kilogram is equal to 1,000 grams.

Motivation

Ask several students how much they weigh. How do they know? Ask the students how they would determine the weight of a pencil or a single sheet of paper. Elicit that each of these is too small to be weighed on a bathroom scale. Develop the need for a more sensitive measuring device.

Procedures

1. Display a triple-beam balance. Explain that this is one of several measuring devices used in the science laboratory.

2. Identify each of the parts of this balance. Include the pan, beams, riders, and indicator line. Demonstrate the operation of each of these parts. Stress the importance of handling this device carefully.

3. Discuss the need for accuracy in determining weight in the science laboratory. Guide students to an understanding of the need for making certain that all weight measurements are taken only after the balance has been set to zero. Demonstrate the use of the knurled knob to be used for this. Explain that balance is achieved when the needle comes to rest at the zero point. As an option, discuss the method of allowing the needle to swing equally above and below the zero mark for balancing.

4. Select a variety of objects for weighing. These should range in weight so that the use of all riders can be demonstrated. It is helpful to have a box of standard metric weights so that weighing results can be verified.

5. Have several students come up and demonstrate the use of the balance for the class.

6. Demonstrate the use of the double-pan balance. Instruct pupils in how to determine the zero point on this balance.

Summary Questions

1. What is the basic unit of weight in the metric system?
2. What part of a kilogram is a gram?
3. When is it convenient to express weight in kilograms rather than grams?

Optional Activity

Have a student report on the difference between the concepts of weight and mass.

Lesson 9 The Triple-Beam Balance

Laboratory Exercise

Aim: How are objects weighed on the triple-beam balance?

Materials

triple-beam balance, student laboratory worksheet, assortment of numbered objects (stones, wood, etc.)

Outcomes

A triple-beam balance is a weighing device containing three scales (beams).

Materials are weighed on the triple-beam balance by placing these on a pan after the pointer has been set at zero, and then moving the riders until the pointer is again at zero.

The weight of an object on the triple-beam balance is the sum of the weights indicated on all three beams.

Procedures

1. Distribute materials and student laboratory worksheets.

2. Discuss the function of each of the beams. Develop that:
   a. The first (front) beam is divided into ten equal parts; each representing one gram.
   b. The second (middle) beam is divided into five parts; each representing 100 grams.
   c. The third (rear) beam is divided into ten parts; each representing ten grams.

3. Distribute (as unknowns) objects you have weighed previously and whose weights are to be determined. (Painted numerals are suggested.) The numbers and weights should correspond to a list kept by you.

Summary Questions

1. Without using additional weights, what is the heaviest weight that can be determined on the triple-beam balance?
2. Describe the weight range for each beam.
3. What are the smallest subdivisions representing weights on each beam?
4. What was the increase in weight of the beaker when you added 50 ml of water? Explain your answer.
5. What is the relationship between the weight and volume of a given quantity of water?

Lesson 9 The Triple-Beam Balance

Student Laboratory Worksheet

Name ______________________ Date __________ Section _______

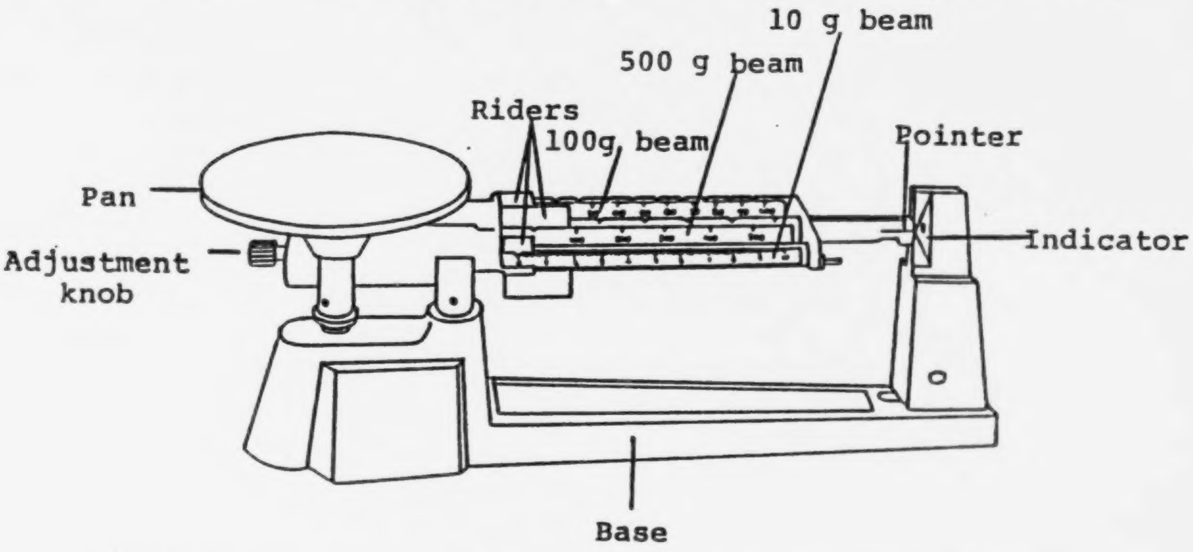
Aim: How are objects weighed on the triple-beam balance?

Materials

triple-beam balance, assorted objects for weighing, 100 ml graduated cylinder, 100 ml beaker

Procedures

1. Identify the various parts of the balance as well as the function of each of these parts. Include the pan, beams, riders, pointer and pointer scale, and the knurled adjustment knob. Compare your balance with the diagram below.


10 g beam
500 g beam
Riders
100g beam
Pointer
Pan
Indicator
Adjustment knob
Base

2. Make certain that all riders are at the zero position before you begin. Weigh each of the objects provided by your teacher. Enter the object number and the weight in the table below.

Object Number	Weight

3. Place a 100 ml beaker on the pan. Determine the weight of the beaker. Enter the weight of the beaker below. DO NOT REMOVE THE BEAKER FROM THE PAN!

weight of beaker = _______ grams

4. Using the 100 ml graduated cylinder, carefully place 50 ml of water into the beaker. Determine the combined weight of the beaker and water. Enter this below.

weight of beaker and water = _______ grams

5. Calculate the weight of the water alone.This can be done by subtracting the weight of the beaker from the combined weight of the beaker and water. Enter the weight of the water below.

weight of water = _______ grams

Summary Questions

1. What is the relationship between the volume of water and the gram weight?
2. Why is the triple beam balance referred to as a balance?
3. What is the function of the riders?
4. What must be done in order to determine the weight of a substance in a container?

Lesson 10 The Double-Pan Balance

Laboratory Exercise

Aim: How are objects weighed on the double-pan balance?

Materials

double-pan balance, set of standard weights, assortment of numbered objects (for weighing), 50 ml beaker, 100 ml graduated cylinder, rubber stopper

Outcomes

A double-pan balance has two pans, one for the object being weighed, the other for weights added to balance the object.

A double-pan balance contains a rider and beam calibrated in tenths of a gram (to a total of ten grams) which are used for final balancing.

A knurled adjustment knob is used (as with the triple-beam balance) to bring the balance pointer to zero before weighing begins.

Motivation

Ask the class how a seesaw works, and what must be done to make the heavy end rise and balance. Introduce the double-pan balance as an instrument which operates on the principle of the seesaw.

Procedure

1. Display the double-pan balance. Review the various parts of the balance as well as the function of each of these parts. Include the pans, pointer, rider, beam, and knurled adjustment knob.

2. Review the proper method for using the adjustment knob to bring the pointer to zero. The pans are balanced when the pointer remains at the zero indicator. As an option, discuss the method of allowing the needle to swing equally to the left and right of the zero mark.

3. Review the use of the rider and beam. Demonstrate their use by placing a rubber stopper on the left pan and weighing it by moving the rider beam to the right until the swings of the needle indicate that balance has been achieved.

4. Distribute laboratory worksheets and materials.

Summary Questions

1. How is the double-pan balance similar in principle to the seesaw?
2. Which balance (triple-beam or double-pan) is more accurate?

Lesson 10 The Double-Pan Balance

Student Laboratory Worksheet

Name ______________________ Date _________ Section _________

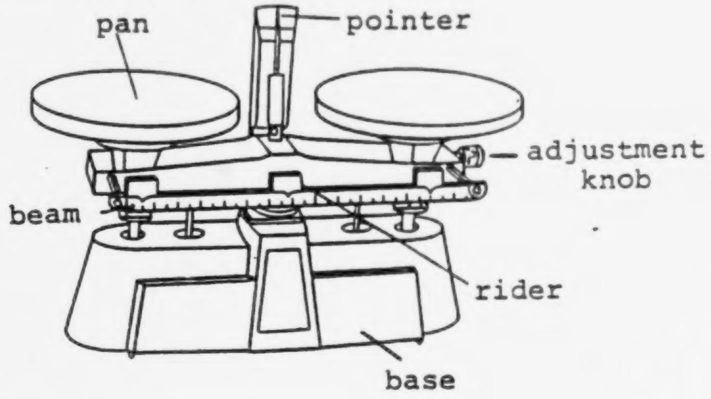
Aim: How are objects weighed on the double-pan balance?

Materials

double-pan balance, 50 ml beaker, 100 ml graduated cylinder, set of standard weights, assorted objects for weighing

Procedures

1. Study your laboratory balance and compare it to the illustration below. Identify the parts that are labelled.



2. Prepare your balance by turning the knurled adjustment knob so that the pointer rests on zero.
3. Place the 50 ml beaker on the left pan of the balance. Add enough weights to the right pan to balance the beaker as observed from the swings of the needle. Handle the weights with forceps.

   If necessary, complete the balance by using the scale in grams with the rider.
4. Pour 25 ml of water from the graduated cylinder into the beaker and determine the weight of the water.
5. Weigh each of your unknown objects. Use the following as as guide:
   a. Place the object on the left pan of the balance.
   b. From your standard set of weights, select a weight that most nearly equals the weight of the object.
   c. Place this on the right pan of your balance. (The standard must be slightly lighter than the unknown.)

   d. Complete the balancing by using the rider until the pointer rests at zero.
   e. The sum of the standard weights and the rider weight is the weight of the unknown.

6. Repeat the above procedures for the remaining unknowns. Enter your results in the table below.

Object Number	Weight

Summary Questions

1. Why are standard weights necessary for use with the double-pan balance?
2. How is the rider used to refine the obtained weight on the double-pan balance?

Lesson 11

Density

Laboratory Exercise

Aim: How may objects of equal volume have different weights?

Materials

double-pan balance, 1 cubic centimeter (each) of Fe, Cu, Al, and Mg, 2-100 ml beakers, 100 ml graduated cylinder, set of metric weights

Outcomes

Density is the ratio of the mass per unit volume of a substance.

Density is found by dividing the mass of a substance by its volume.

Density can be expressed in grams per cubic centimeter.

Motivation

Display cubes of iron and aluminum, but do not identify these. Ask students to suggest which of the two cubes is heavier. Point out that since both cubes have identical dimensions, they should have the same weight. Weigh each of the cubes. Students will observe that one cube (Fe) is heavier than the other (Al). Challenge them to explain their observation.

Procedures

1. Review the concept of the atom and the molecule. Guide students to an understanding that density is a measure of the masses of the molecules which compose a material and the closeness with which they are packed together.

2. Explain that the cube of iron is heavier than the aluminum cube because iron atoms are heavier than atoms of aluminum.

3. Define density as a ratio of mass per unit volume of a substance. Explain that the density of a substance can be found using the formula:

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

4. Develop the need for units in calculating density. If mass is expressed in grams, and volume is expressed in cubic centimeters, then density is expressed in grams per cubic centimeter.

5. Distribute materials and student laboratory worksheets. Circulate among the students as they perform the required activities. Lend assistance as required.

Summary Questions

1. Define density.
2. How can density be determined?
3. What units may be used to express density?

Optional Activity

Have the students determine the density of a stone or other small, dense object. Encourage them to compare their results with those of other students who have different types of stones.

Lesson 11

Density

Student Laboratory Worksheet

Name ______________________ Date __________ Section ______

Aim: How may objects of equal volume have different weights?

Materials

2-100 ml beakers, 100 ml graduated cylinder, double-pan balance, alcohol, set of standard metric weights, 1 cc cubes of Fe, Cu, Al, and Mg

Procedures

1. Place a 100 ml beaker on each of the pans of the double-pan balance. Adjust your balance so that the pointer is at zero.
2. Using a graduated cylinder, pour 100 ml of water into the beaker on the left pan.
3. Use the set of standard weights to determine the weight (mass) of the water. Enter the mass and volume in the following table.

Liquid	mass (g)	Volume (cc)	density (g/cc)
water			
alcohol			

4. Repeat steps 1-3. This time, use alcohol instead of water. Enter the mass and volume in the table.
5. Calculate the density for each of the liquids. Use the formula

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Enter the density of each liquid.

6. Weigh each of the metal cubes. For each, record the mass and volume. Enter this data in the following table.

Metal	Mass (g)	Volume (cc)	Density (g/cc)
iron (Fe)			
copper (Cu)			
aluminum (Al)			
magnesium (Mg)			

7. Calculate the density for each and enter this in the above table.

Summary Questions

1. How do the densities of water and alcohol compare?
2. Which of the metals studied has the highest density? The lowest density?
3. In your experiment, how do the volumes of the liquids compare?
4. How do the volumes of the metals compare?
5. How can materials of equal volumes have different weights?

Lesson 12

The Bunsen Burner

Laboratory Exercise

Aim: What are the parts of the Bunsen burner?

Materials

Bunsen burner, safety matches, student laboratory sheets, cross-sectional wall chart of Bunsen burner (prepared)

Outcomes

The parts of the Bunsen burner control both the flow and mixing of fuel gas and air.
A yellow, sooty flame is cool and results from insufficient oxygen to oxidize all of the fuel gas being supplied.
A blue flame is hot and results from complete oxidation.
Both height and color of the Bunsen burner flame can be controlled.

Motivation

Exhibit a tray containing Bunsen burner parts. Ask, "What is this?" Upon identification by class, re-assemble the burner and elicit how it is used in the laboratory.

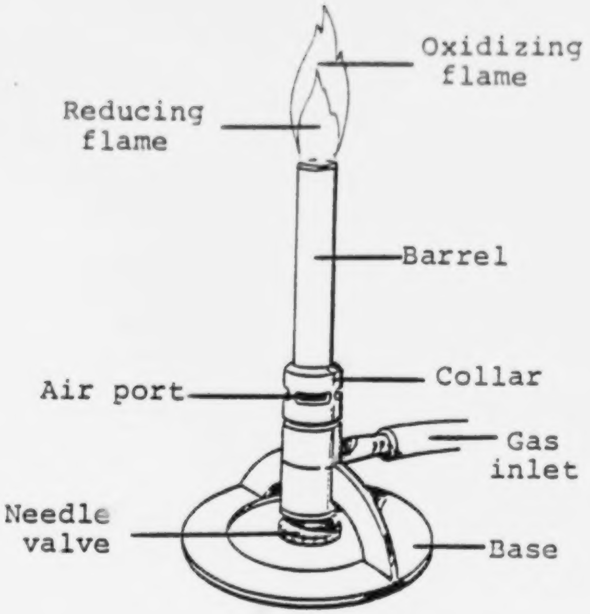
Procedures

1. Distribute the student laboratory worksheets.

2. With the aid of a Bunsen burner chart, have students refer to the burners at their tables. Encourage students to label and describe the function of each of the parts. The parts and functions are included below.

Parts and Functions of the Bunsen Burner

Part	Function
rubber tubing	carries gas to burner
needle valve	controls flow of gas
barrel	conducts mixture of gas and air to opening at top of burner
air port	controls flow and amount of air to enter barrel
collar	located at base of barrel, contains the air ports
base	supports the burner
spud	the part of the base which holds the barrel



3. Demonstrate the proper procedure for lighting a Bunsen burner. Stress the following safety precautions:
    a. Connect rubber tube from burner to gas jet.
    b. Make certain burner needle valve and air ports are partly open.
    c. Strike a match, first making certain that match box is securely closed.
    d. Light burner by moving lighted match upward along the side of the barrel to its top.
    e. Turn gas jet on and burner will light. Remember that a burner flame is almost invisible in a well-lighted room. Caution students not to lean over the burner while lighting it.

4. Demonstrate the procedure for adjusting the burner flame:
    a. Turn Bunsen burner collar to increase air intake for blue flame and decrease it for yellow flame.
    b. Turn needle valve to control the height of the flame.
    c. Point out the problem of strike-back (flame ignites where the gas enters the barrel). Should this occur, jet should be turned off and the barrel allowed to cool before handling. Strike-back can be corrected by partially closing the air ports. This should be attempted only after the barrel has cooled.

Summary Questions

1. Why is it important that the burner tubing be free of holes?
2. Why should the needle valve be used to control gas flow rather than the supply (outlet) valve?

3. Describe the use of the barrel. Explain how turning the barrel controls the intake of air.
4. Which is the hotter flame, yellow or blue?
5. Which of the two types of flame requires more air?

Optional Activity

Discuss the parts and functions of various types of laboratory burners (e.g., Fisher, Meeker). If time permits, demonstrate the use of these.

Lesson 12 The Bunsen Burner

Student Laboratory Worksheet

Name ______________________________ Date ___________ Section ________

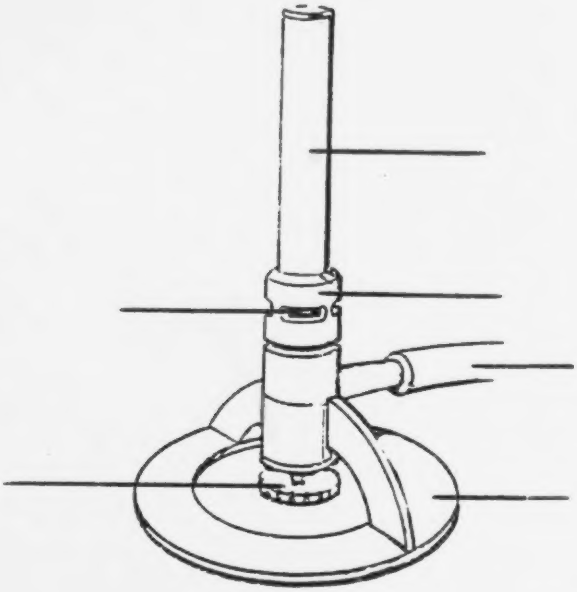
Aim: What are the parts of the Bunsen burner?

Materials

Bunsen burner, nichrome transfer needle, safety matches, wing tip

Procedures

1. Compare your Bunsen burner to the illustration below. Study each carefully. Label the parts of the burner on the drawing.

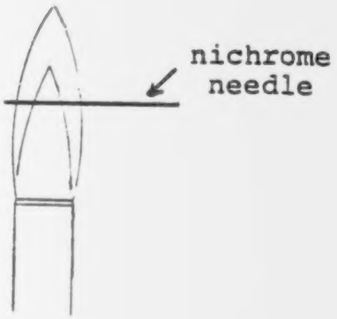


2. Review the function of each of the parts labelled. Enter the part name and its function in the following table.

Part	Function

3. Light the burner and carefully adjust the flame. The flame should be approximately 5 cm high and pale blue in color.

   Place the nichrome transfer needle across (through) the flame as shown.



   a. Observe the color change in the needle. Which parts of the needle change color?

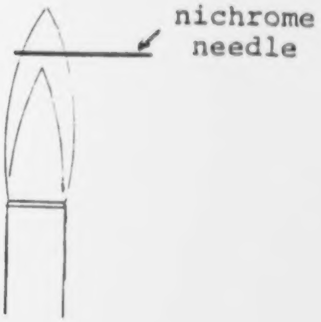
   ____

   ____

   b. Where is the hottest part of this flame? ____________
   The coolest? ____________
   How do you know? ____________

   ____

4. Place the needle through the upper part of the flame.



   a. What happens to the needle?

   ____

   b. What can you conclude about this part of the flame?

   ____

   ____

5. Turn off the burner. Slide the wing tip over the top of the barrel. Re-light the burner at the opening of the wing tip.

   Describe the type of flame produced by the wing tip.

   ____

   ____

   How does this flame compare to the flame produced without the wing tip?

Summary Questions

1. How is air flow controlled in a unsen burner?
2. Which part of the unsen burner flame appears to be the coolest? The hottest? How do you know?
3. What is the function of the needle valve?

Lesson 13 Glass Tubing: Cutting, Fire Polishing, and Flanging

Laboratory Exercise

Aim: How can glass tubing be cut, fire polished, and flanged to make useful laboratory glassware?

Materials

lengths of 6 mm (inside diameter) glass tubing, metric ruler, triangular file, Bunsen burner, tile square, safety matches, safety goggles

Outcomes

Glass tubing can be cut into various lengths.
Fire polishing is a technique used to smmoth and round the ends of glass tubing.
Flanging is the flaring of one end of a glass tube through the use of heat.

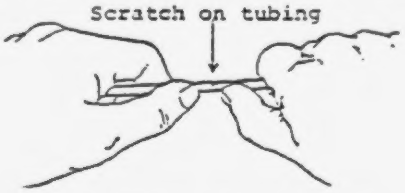
Motivation

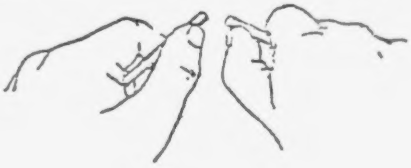
Display a length of standard, 6 mm glass tubing alongside a short length of fire polished tubing with a flange at one end. Ask several students to feel the ends of both and describe the differences. Ask them if they could change the 6 mm tubing to look like the fire polished sample.

Procedure

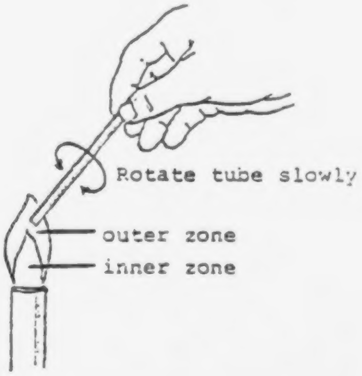
1. Using the triangular file, demonstrate the proper technique for making a scratch on the glass tubing.

2. Show how the glass tubing may be broken by pressing firmly on the tube opposite the scratch.

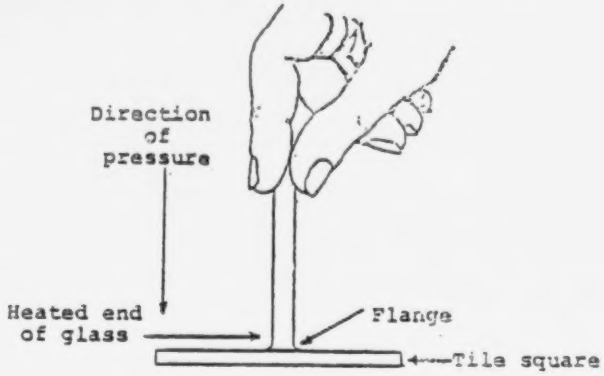




3. Demonstrate the technique of fire polishing a piece of glass tubing. Call attention to the advantage of holding the tubing in the hottest part of the burner flame (above the tip of the inner cone). Glass should be allowed to cool safely on a tile square.



4. Demonstrate the flanging technique. Gently but firmly press the previously softened tube end downward against a tile square. Emphasize the importance of holding the tubing perpendicular to the tile. Caution students that hot glass cools slowly and may cause painful burns. Glass must be left on the tile square until it cools enough to be handled safely.



Summary Questions

1. What is the purpose of scratching glass tubing before breaking it?
2. Why is fire polishing important in preparing laboratory glassware?
3. What precautions should be taken when working with heated glassware?

Lesson 13 Glass Tubing: Cutting, Fire Polishing, and Flanging

Student Laboratory Worksheet

Name ______________________ Date ___________ Section ________

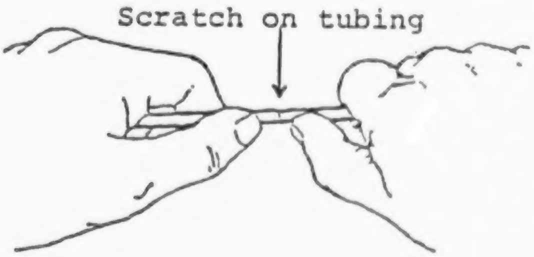
Aim: How can glass tubing be cut, fire polished, and flanged to make useful laboratory glassware?

Materials

glass tubing, triangular file, Bunsen burner, tile square, safety matches, safety goggles, metric ruler

Procedures

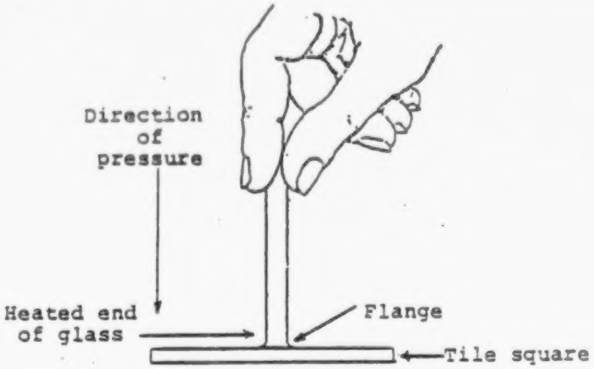
1. Put on your safety goggles before performing the following activities.
2. Use your metric ruler to measure a length of 13 cm on a piece of glass tubing.
3. Use the triangular file to make a scratch on the glass at the 13 cm mark.
4. Hold the glass tubing as shown. Press firmly against the side opposite the scratch. Break the glass.



5. Light your burner and adjust to a low flame. Place one of the ends of the glass tubing in the flame. Slowly rotate the tubing until the end in the flame appears rounded.

6. Place the softened end of the tubing against the surface of the tile square. Firmly and evenly press the tube down against the tile. You may want to practice this method of flanging several times (using different pieces of tubing for each trial).

   CAUTION: Hot glass cools slowly and can cause severe burns.



7. Allow your piece of tubing to cool on the tile square.

8. After several minutes, fire polish the other end of the tubing.

Summary Questions

1. What happens if we keep the end of a piece of glass tubing in the flame too long?
2. What purpose does flanging have in the preparation of laboratory glassware?

Lesson 14 Glass Tubing: Bending and Drawing

Laboratory Exercise

Aim: How can glass tubing be bent and drawn into thin tubing?

Materials

length of glass tubing, triangular file, Bunsen burner, wing tip, fine file, safety matches, safety goggles

Outcomes

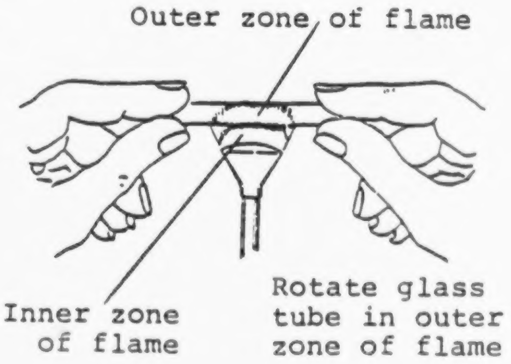
Glass tubing can be softened and bent using a Bunsen burner.
Glass tubing can be drawn into thin tubes called capillary tubes.

Motivation

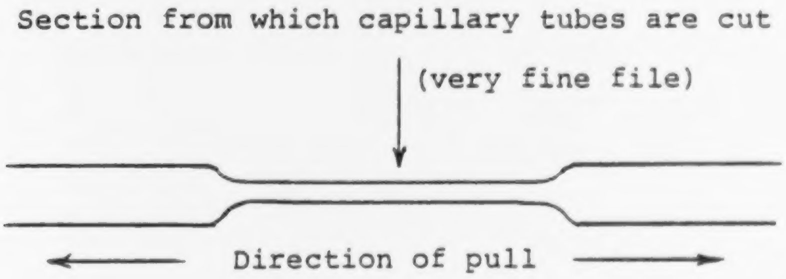
Display a length of capillary tube. Explain that it is often necessary to use thin tubing in the laboratory. Tell the students that standard glass tubing (6 mm) may be used to prepare capillary tubes.

Procedures

1. Have students recall the correct method for attaching the wing tip to the Bunsen burner. Stress that the burner should be lighted *only after the wing tip is in place*. Demonstrate the process of heating a piece of glass tubing (about 20 cm long) to the proper degree of softness and then bending the glass into the desired shape on the tile square. Remind students that *hot glass cools slowly* and may cause painful burns. Glass must be left on the tile square until it cools enough to be handled safely (about 5 minutes).



2. Demonstrate the drawing out of a heated glass tube to produce a capillary tube. Heat-soften glass tubing. When the proper degree of softness is obtained, a quick, straight, outward pull on the ends of the glass tubing results in a section of thin tubing. Allow the tubing to cool for about 5 minutes. Cut the tubing into 6 cm lengths and store for later use.


Section from which capillary tubes are cut
(very fine file)
Direction of pull

3. Distribute student materials and laboratory worksheets.

Lesson 14 Glass Tubing: Bending and Drawing

Student Laboratory Worksheet

Name ______________________ Date _________ Section __________

Aim: How can glass tubing be bent and drawn into thin tubing?

Materials

length of glass tubing, triangular file, fine file, tile square, Bunsen burner, wing tip, metric ruler, safety goggles, safety matches

Procedures

1. Cut and fire polish two 20 cm lengths of glass tubing. Allow each to cool for 5 minutes.

2. Shut off the burner and set the wing tip in place. Light the burner. Heat a piece of tubing to the proper degree of softness and bend to the desired shape. Allow to cool.

3. Heat the second length of glass tubing. When soft, remove it from the flame and quickly pull outwards on the ends. Allow to cool.

4. Using the fine file, scratch and break the thin section of the tubing into 6 cm lengths. Store for future use.

Summary Questions

1. What is the function of the wing tip?
2. What is the advantage of bending the glass tubing on the tile square rather than bending it freely in the air?
3. What may happen if you pull very slowly on the heated glass?
4. Why must you use a fine file rather than the triangular file when cutting capillary tubes?

Lesson 15 The Thermometer

Laboratory Exercise

Aim: How do we use a thermometer in the laboratory?

Materials

thermometers containing Fahrenheit and Celsius scales, student laboratory worksheets, absorbent cotton, string, alcohol, 2-500 ml beakers, ice cubes, Bunsen burner, tripod, wire gauze, safety matches

Outcomes

Temperature is a measure of the amount of heat being given off by a substance.
The Fahrenheit and Celsius scales are used to measure temperature.
A thermometer is an instrument used to measure temperature.

Motivation

Ask students to recall when they were ill and running a fever. Ask them to explain how temperature measurements (if taken) were obtained. Elicit that a thermometer is used to measure temperature.

Procedures

1. Review the concept that molecules are in constant motion. Develop the understanding that heat is a form of energy that results from the movement of molecules.

2. Distribute thermometers and student laboratory worksheets.

3. Call attention to the fact that a thermometer is an instrument used for measuring temperature. It consists of a liquid-filled (alcohol or mercury) sealed glass tube containing a bulb at one end. As temperature increases or decreases, the liquid expands or contracts, rising or falling in the tube.

4. Call attention to sample points on each of the thermometer scales, e.g., room temperature, body temperature, boiling and freezing point of water.

5. Identify the boiling and freezing points of water. On the Celsius scale, also called Centigrade, the freezing point of water is 0° C, while the boiling point of water is 100° C. These temperatures on the Fahrenheit scale are 32° F and 212° F respectively.

6. Develop the concept that one degree F is equal to 5/9 of a degree C. A degree C is equal to 9/5 of a degree F. Temperatures on the two scales can be converted from one to the other by the formulas:

$$F = 9/5\ C + 32$$

$$C = 5/9\ (F - 32)$$

Summary Questions

1. What is the relationship between the speed of movement of molecules, their energy, and their temperature?
2. In which system, Fahrenheit or Celsius, are there more degrees (divisions) between the freezing and boiling points of water? In which system, therefore, does each degree represent a greater change in temperature?

Lesson 15 The Thermometer

Student Laboratory Worksheet

Name ______________________________ Date ____________ Section ________

Aim: How do we use a thermometer in the laboratory?

Materials

thermometers, absorbent cotton, string, alcohol, 2-500 ml beakers, tripod, wire gauze, bunsen burner, safety matches, ice cubes

Procedures

1. Carefully study the thermometer. Identify the Fahrenheit and Celsius scales. What is the room temperature on the Celsius scale? ____________ On the Fahrenheit scale? ____________

2. Gently press the thermometer bulb between your fingers. What happens to the liquid column in the thermometer?
   ____
   Where does this heat energy come from? ____________________
   ____

3. Use a length of string to fasten a small piece of cotton around the thermometer bulb. Wet the cotton with alcohol. Observe the liquid column for several minutes. What happens to the temperature as the alcohol evaporates?
   ____

4. Fill one of the 500 ml beakers 3/4 full with water. Heat the water to boiling over a Bunsen burner flame. Record the temperature of the water as it boils. At what temperature does the column of liquid stop rising? What is the temperature of the boiling water in degrees C? ____________ In degrees F? __________ Shut the burner and allow the water to cool.

5. Fill the second beaker 1/2 full with water. Place several ice cubes into the water. Stand the thermometer in the beaker of ice water. Record the temperature of the water when the liquid column stops falling. What is the temperature of the ice water in degrees C? ____________ In degrees F? __________

6. Calculate the following temperature conversions. Use the formulas:

$$F = 9/5\ C + 32$$

$$C = 5/9\ (F - 32)$$

a. 21° C = _____ $^{\circ}$F

b. 37°C = ______ $^{\circ}$F

c. 32°F = _____ $^{\circ}$C

d. 212°F = _____ $^{\circ}$C

Summary Questions

1. What is temperature?
2. How does the Fahrenheit temperature differ from the Celsius scale?
3. Why is it necessary to allow time to pass before reading the temperature of ice water or boiling water?
4. Why does absorbent cotton from which alcohol is evaporating quickly become cooler? How does this evaporation principle apply to the treatment of small animals with a high fever?

Lesson 16 Solutions

Laboratory Exercise

Aim: What are some properties of solutions?

Materials

several sample solutions in 250 ml Erlenmeyer flasks: salt in water, concentrated (viscous) sugar solution, two copper sulfate solutions (concentrated and dilute), triple-beam balance, 250 ml beakers, stirring rods, 100 ml volumetric flasks, four -inch squares of glossy paper, salt, sugar, copper sulfate crystals, funnels, filter paper

Outcomes

A solution is a homogeneous mixture of a solute and a solvent.
The substance which is dissolved is called the solute, while the one in which it is dissolved is called the solvent
In solutions, solutes are molecular in size.
Solutions are clear and transparent.

Motivation

State that very often a druggist will confer with a physician regarding the concentration of a prescribed drug. Elicit why this is important.

Procedures

1. Display several previously prepared solutions. State that these are solutions and elicit their characteristics, e.g., clear, transparent, uniform throughout (homogeneous), viscosity.

2. Identify the parts of a solution. Explain the concept of solute and solvent. Guide students to an understanding that the dissolved substance is referred to as the solute, and the substance in which it dissolves is called the solvent.

3. Explain that water is often called the universal solvent since most solutes readily dissolve in it. State that alcohol, ether, and benzene are other examples of solvents.

4. Demonstrate the filtration of a concentrated copper sulfate solution. Have the students observe that both solute and solvent pass through the pores of the filter paper. Elicit that in a solution the solute particles are molecular in size.

5. Introduce the concept of concentration by asking which contains more solute, a viscous solution of sugar or a more freely flowing one; a darker or lighter solution of copper sulfate. Introduce the concept that in a solution, the more concentrated the solute, the more slowly the solution may flow. It is then said to be viscous or to have a high viscosity. A less concentrated solution may flow more readily; it has a low viscosity.

6. Explain that the total weight of solute in a given volume of solution is referred to as the concentration of the solution. Explain that a percent solution is one having a certain weight of solute in 100 ml of solvent.

7. Demonstrate the procedures used in the preparation of a percent solution.

8. Distribute student materials and laboratory worksheets.

Summary Questions

1. Define the terms: solute, solvent, viscosity, and concentration.
2. What is a percent solution?
3. What are the procedures for preparing a percent solution?

Optional Activity

Have students prepare both 9% and 0.9% NaCl solutions. Mention that the 0.9% NaCl is referred to as normal saline, having the same osmotic pressure at least as some mammalian blood cells.

Lesson 16 Solutions

Student Laboratory Worksheet

Name ______________________ Date __________ Section ______

Aim: What are some properties of solutions?

Materials

triple-beam balance, glossy paper, spatula, sodium chloride, 250 ml beaker, 100 ml graduated cylinder, glass stirring rod, funnel, 2-100 ml volumetric flasks, 10 ml pipette

Procedures

1. Prepare a 5% NaCl solution as follows:
   a. Place a square of glossy paper on the pan of the triple-beam balance.
   b. Use the knurled knob to return the balance to zero.
   c. Weigh out 5 grams of sodium chloride.
   d. Pour the sodium chloride into a beaker containing 50 ml of water.
   e. Stir with a stirring rod until all of the salt dissolves.
   f. With the aid of a funnel, transfer the salt water solution to a 100 ml volumetric flask.
   g. Carefully add water to the 100 ml mark. Label the flask, date it, and stopper.

2. Using the solution just prepared (5% NaCl), how can you now prepare 100 ml of a 0.5% NaCl solution? ______________

   ____

   ____

3. Prepare a 0.5% NaCl solution from the 5% NaCl solution as follows:
   a. Pipette up 10 ml of the 5% NaCl solution and discharge it into a clean 100 ml volumetric flask.
   b. Add water to the 100 ml mark. Label the flask, date it, and stopper.

Summary Questions

1. Describe how you would prepare a 15% sugar solution.
2. What are some properties of solutions?
3. Which is more dilute, a 5% salt solution or a 0.5% salt solution?
4. Why would precise measurement be important in preparing percent solutions to be used on small animals?

Lesson 17 Suspensions

Laboratory Exercise

Aim: What are some properties of suspensions?

Materials

bottle of clear medicine, bottle of calamine lotion, starch-water mixture, sand-water mixture, soap mixture, flashlight, sand, starch, 3 large test tubes with stoppers, ring stand, small support ring, filter paper, 3-50 ml beakers, Congo red

Outsomes

A suspension is a mixture in which the suspended particles are insoluble and eventually settle or can be filtered out
Suspensions differ in particle size and rate of settling
A colloid is a special kind of suspension in which the particles do not settle and are not filterable

Motivation

Display bottles of clear medicine and calamine lotion. Have a student volunteer note that the calamine label reads, "SHAKE WELL BEFORE USE", while that of the clear medicine does not. Ask why the calamine lotion must be shaken. Elicit that the particles have settled to the bottom of the bottle.

Procedures

1. Develop the idea that suspensions such as calamine lotion are mixtures in which the suspended particles settle out on standing.

2. Demonstrate that the rate of settling depends upon the nature of the suspended particles. Display bottles of starch and water, and sand and water. Elicit which of the particles is heavier (sand or starch). Shake both bottles vigorously and place them so that they are clearly visible to the class. Challenge students to explain what happens.

3. Display a test tube containing a soap-water mixture. Have students note the cloudiness of the mixture. Develop the idea that it is more like a suspension than a true solution. Darken the room and shine a beam of light through the mixture. Develop the understanding that the beam is reflected by particles too small to settle out. Identify this type of mixture as a colloid.

4. Distribute student materials and laboratory worksheets.

Summary Questions

1. How do solutions and suspensions differ?
2. What is a colloid?
3. What causes differences in the rate of settling in different suspensions?
4. Many medicines are suspensions. Why must these be shaken before use?
5. Explain the basic difference between colloids and other kinds of suspensions.

Lesson 17

Suspensions

Student Laboratory Worksheet

Name ______________________ Date ________ Section __________

Aim: What are some properties of suspensions?

Materials

sand, starch, Congo red, 3 test tubes with stoppers, ring stand, small support ring, filter paper, 3-50 ml beakers, test tube rack, spatula

Procedures

1. Place about 1 cm of starch into one of the test tubes. Fill the test tube 2/3 full with water.
2. Stopper the test tube and place it in the test tube rack.
3. Place about 1 cm of sand into a second test tube. Fill this test tube 2/3 full with water.
4. Stopper this test tube and place it in the test tube rack.
5. Shake both test tubes vigorously and observe them for about 1 minute.
    a. How do both mixtures appear immediately after shaking?

    ____

    ____

    b. After 1 minute, how does each of the mixtures appear?

    ____

    ____

    Explain why. ______________________________________

    ____
6. Set up the ring stand and support ring. Set the funnel and filter paper in place. Place one of the 50 ml beakers under the funnel.
7. Filter the starch-water suspension. What collected in the filter paper? ______________________

    What collected in the beaker? ______________________

8. Change the filter paper and beaker. Filter the sand-water mixture. What collected in the filter paper? ______________

   What collected in the beaker? ______________________

   a. What can happen to the particles in a suspension?

   ____

9. Change the filter paper and beaker. Filter a small amount of the Congo red. Compare the liquid in the beaker with the liquid in the container. How do they compare?

   ____

   a. Explain your results. ________________________

   ____

Summary Questions

1. What are some properties of a suspension?
2. What are some properties of a colloid?
3. How do suspensions and colloids differ?

Lesson 18 Acids and Bases

Aim: What are acids and bases?

Materials

acid solutions: HCl, H_2SO_4, HNO_3, base solutions: NaOH, NH_4OH, $Ca(OH)_2$

Outcomes

An acid is a substance which produces hydrogen (H^+) ions in solution.

A base is a substance which produces hydroxide (OH^-) ions in solution.

Procedures

1. Display several acid solutions and place the formula for each acid on the board. Challenge students to explain how each of the formulas is similar. Elicit that each contains hydrogen.

2. Display several bases. Place the formulas for each base on the board. Again challenge students to explain how each of the formulas is similar. Elicit that each contains an OH group.

3. Place the following on the board:

$$HCl \longrightarrow H^+ + Cl^-$$

$$HNO_3 \longrightarrow H^+ + NO_3^-$$

Explain that acids dissociate (break apart) into charged atoms or groups of atoms called ions. Identify each of these in the above formulas.

4. Place the following on the board:

$$NaOH \longrightarrow Na^+ + OH^-$$

$$NH_4OH \longrightarrow NH_4^+ + OH^-$$

Explain that bases dissociate into charged atoms or groups of atoms called ions. Identify each of these in the above formulas.

5. Identify the H^+ ion as the hydrogen ion. Identify the OH^- ion as the hydroxide ion. Explain that it is possible to measure the concentration of each of these ions.

6. Develop the understanding that when H^+ and OH^- ions are present in equal numbers, a solution is neither acid nor base; it is neutral. For example:

$$H^+ + OH^- \rightleftharpoons HOH \text{ (water)}$$

7. Explain that a substance that dissociates to form H^+ ions is referred to as an acid. Bases dissociate to form OH^- ions.

Summary Questions

1. What is the symbol for the hydrogen ion?
2. What is the symbol for the hydroxide ion?
3. How can an acid be identified by its formula?
4. How can a base be identified by its formula?

Lesson 19

Indicators

Laboratory Exercise

Aim: How do we use indicators?

Materials

red litmus paper, blue litmus paper, phenolphthalein, hydrion paper, brom thymol blue, Florence flask, dilute sodium hydroxide solution, dilute hydrochloric acid, 2-50 ml beakers, medicine droppers, paper towel, student laboratory worksheet

Outcomes

An indicator is a substance which may change color in the presence of an acid or base.
pH is a unit for measuring the strength of an acid or base.
The pH scale ranges from 0-14.
The pH of an acid solution is less than 7.
The pH of a base solution is more than 7.
On the pH scale, 7 is neutral.

Motivation

Prior to class, rinse a Florence flask with sodium hydroxide solution. Discard the liquid. Set the flask on the desk in view of the class. After the class is seated, display a bottle of phenolphthalein. Have the students note that it is colorless. Add some phenolphthalein to the flask. Challenge students to explain what happens.

Procedures

1. Display and identify a variety of indicators. Include such indicators as red litmus paper, blue litmus paper, phenolphthalein, hydrion paper, and brom thymol blue.

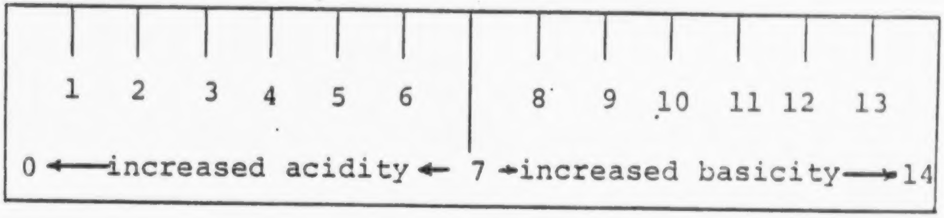
2. Develop the understanding that indicators are substances which may change color in the presence of an acid or base. Tell the students that phenolphthalein was the indicator poured into the flask. Elicit that the color change indicates the presence of an acid or base.

3. Place a small amount of a dilute acid into a 50 ml beaker. Add several drops of phenolphthalein. Students should note that no color change takes place.

4. Place a small amount of dilute base into a 50 ml beaker. Add several drops of phenolphthalein. Students should note that a color change (from colorless to pink) takes place.

5. Identify phenolphthalein as an indicator used to detect the presence of a base. Have students conclude that phenolphthalein changes color (from colorless to pink) in the presence of a base; but remains colorless in an acid.

6. Place the following on the board.



7. Identify the scale as a pH scale, and have the students note that the scale ranges from 0 to 14. Tell the students that the pH of an acid is less than 7; and that the pH of a base is more than 7. Have students note that a pH of 7 is neither acid nor base. It is neutral. Students should recall that neutral indicates equal numbers of H^+ and OH^- ions.

8. Weak acids and bases have a pH closer to 7. Strong acids and bases have a pH closer to zero and fourteen respectively.

9. Develop the understanding that indicators can be used in several ways. Indicators may be used to show whether a solution is acidic or basic. (These are referred to as qualitative indicators.) Indicators may also be used to determine the actual strength (pH) of an acid or base. (These are referred to as quantitative indicators.)

Summary Questions

1. What is an indicator?
2. How may indicators be used?
3. What is the pH scale?
4. What does a pH of 7 indicate?
5. Which is a stronger acid; one with a pH of 2 or of 4?

Optional Activity

Encourage students to research the significance of pH in living systems. How does pH relate to enzyme activity, tissue fluids, and other body functions?

Lesson 19

Indicators

Student Laboratory Worksheet

Name __________________________ Date __________ Section ________

Aim: How do we use indicators?

Introduction

An understanding of indicators and pH measurement is important to people interested in the physiology of living things. Living things require a suitable environment if they are to survive. Very often, a suitable environment includes a proper pH. Such body fluids as blood and urine have a normal pH. This means that if the organism is healthy, the pH of the blood, urine, and other body fluids is maintained at a certain level. Illness may be indicated if the pH becomes higher or lower than these accepted levels. For this reason, a routine medical examination generally includes pH tests.

To a farmer or forester, a knowledge of soil pH is important. To the owner of a tropical fish store. pH is equally important. The life activities of fish, water plants, in fact all living things, require a certain pH. The following laboratory activity is designed to help you become familiar with pH and its measurement.

Materials

lemon juice, sauerkraut juice, 0.1 N acetic acid, 0.1 N sodium hydroxide, vinegar, liquid soap solution, aspirin, egg white, brom thymol blue, 5 test tubes, test tube rack, medicine droppers, forceps, red litmus paper, blue litmus paper

Procedures

1. Study the following table of indicators. You will use the information in the table as you perform your laboratory activities.

Indicator	Color	Change in acid	Change in base	Type of Reading
Litmus paper	blue	blue to red	no change	qualitative
	red	no change	red to blue	qualitative
Phenolphthalein	colorless	no change	colorless to pink	qualitative
Brom thymol blue	blue	blue to yellow	no change	qualitative
Hydrion paper	yellow	Indicator changes color according to pH		quantitative

2. Place 5 test tubes into the test tube rack.
   a. Into the first, place a small amount of brom thymol blue.
   b. Into the second, place a small amount of phenolphthalein.
   c. Into the third, place a strip of red litmus paper.
   d. Into the fourth, place a strip of blue litmus paper.
   e. Into the fifth, place a strip of hydrion paper.

3. Into each of the test tubes, place several drops of lemon juice. Observe the color changes that take place and enter your observations in the table below.

4. Clean each of the test tubes thoroughly and repeat step 2 for each of the remaining substances to be tested. Enter your results in the table.

Test Substance	Indicator Used	Change Shown	Acid or Base	pH
lemon juice				
.1 N acetic acid				
.1 N NaOH				
vinegar				
sauerkraut juice				
aspirin in H_2O				
egg white				

Summary Questions

1. Which of the substances tested are acids?
2. Which of the substances tested are bases?
3. Which of the indicators can be used to identify the numerical pH of a substance?
4. What is a qualitative indicator? List several examples.

Lesson 20 The Compound Microscope

Laboratory Exercise

Aim: What are the parts of the compound microscope?

Materials

compound microscope chart, student compound microscopes, lens tissue

Outcomes

The compound microscope is an optical device which produces enlarged images of objects too small to be seen with the unaided eye.

The parts of the compound microscope are designed to perform specific functions which contribute to the production of an enlarged image.

Motivation

Discuss the importance of the microscope. Elicit that the microscope has allowed scientists to explore life and living things at a level never before attained.

Procedures

1. With the aid of a wall chart and a compound microscope, conduct a review of the parts of the compound microscope and their functions. Use the following as a guide.

Part	Function
Ocular	Magnifies image produced by objective.
Body tube	Holds the ocular and objectives; maintains a discrete distance between the lenses for focusing light, prevents interference from outside light.
Coarse adjustment knob	Moves the body tube up and down for approximate focus.
Fine adjustment knob	Moves the body tube a short distance for fine focus.
Revolving nosepiece	Turns to change objectives.
Objectives	Contain lenses that magnify specimen either 10X (low power) or 40X (high power).
Stage	Supports the slide. Opening permits light to pass through.
Stage clips	Holds the slide in place.
Diaphragm	Controls the amount of light passing through specimen.

Inclination joint	Permits tilting for convenient viewing.
Mirror	Captures light and reflects it upward through the diaphragm and stage opening.
Base	Supports the microscope.
Arm	Supports the body tube and is used as a handle to carry the microscope.

2. Discuss the precautions in handling and use as contained on the student laboratory sheets.

3. Demonstrate the proper technique for assuring that objectives and slide are not damaged by collision with each other:
    a. Watch descending objective from one side as the body tube is racked down.
    b. Switch to high power objective while watching from the side to avoid objective striking the slide.

Summary Questions

1. How can we differentiate between high and low power objectives?
2. Suggest three ways to avoid damage to the objectives.
3. When is a microscope parfocal? How does this affect focus?

Lesson 20 The Compound Microscope

Student Laboratory Worksheet

Aim: What are the parts of the compound microscope?

Introduction

The compound microscope is a delicate instrument. Certain precautions must be observed in the handling and use of this instrument. Some of the more important precautions and instructions for the use of the microscope are contained below. You should become thoroughly familiar with these before you begin working with your microscope.

a. The microscope should be carried by the arm and base. It should be held close to your body when walking with it.

b. Lens tissue should be used to clean the surfaces of lenses, slide, cover slips, condenser, and mirror before and after use.

c. The coarse adjustment knob should never be used to lower the body tube unless you are constantly aware of the distance between the objective and the slide.

d. Because of the danger of collision between the objective lens and the slide, the coarse adjustment knob should never be used when the high power objective is in place.

e. Before switching objectives from low to high power, adjustment of the diaphragm and mirror must be made to increase the amount of light. Care must be taken to prevent direct sunlight from being reflected through the specimen. When switching from low to high power, carefully check the clearance between the high power objective and the slide.

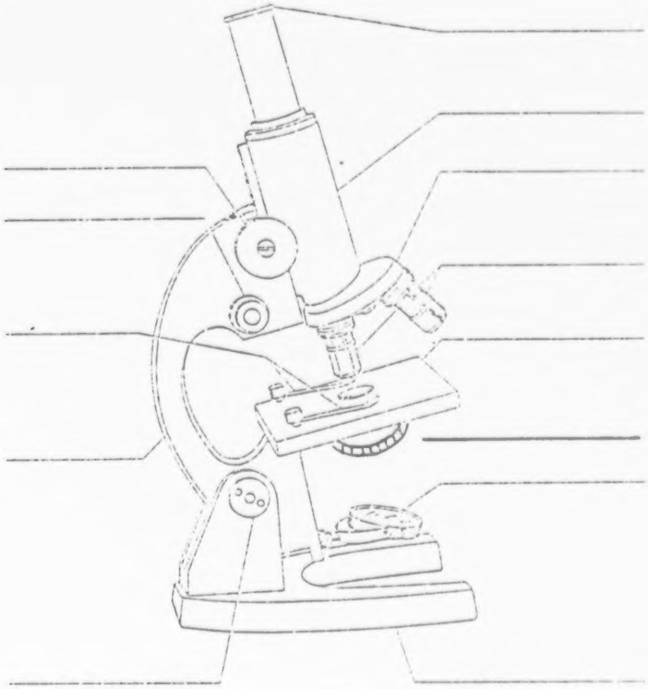
f. If the microscope is parfocal, when the high power objective is rotated into place, after focus has been obtained under low power, the image under high power is immediately in focus. If the microscope is not parfocal, a half-turn of the fine adjustment knob should be enough to arrive at high power focus.

Materials

microscope, prepared slide of letter "e"

Procedures

1. Identify and label the parts of the microscope on the diagram below.



2. Use lens paper to clean all of the lenses and the mirror.
3. Click the low power objective into position. Use the coarse adjustment knob and move the body tube all the way down.
4. Set the diaphragm to the largest opening.
5. Look through the ocular and adjust the mirror to the brightest amount of light.
6. Place the prepared slide on the stage of the microscope. Secure it over the opening in the stage (use the stage clips).
7. While looking through the ocular, slowly raise the body tube. Stop when the object comes into focus. Focus using the fine adjustment knob.
8. While looking through the ocular, slowly and carefully move the slide to the right. In which direction does the object move when viewed through the ocular? ______________

9. Carefully move the slide to the left. What do you notice?
____

10. Move the slide forward and back. What do you notice?
____

11. What general rule applies when moving a slide under the microscope? ____________________________

12. Click the high power objective into position. Focus using the fine adjustment knob. (You should not have to turn the knob more than 1/4 turn in either direction.)

13. What happened to the brightness of the light in your field? ____________________________

14. Remove the slide and clean the lenses of the microscope. Rotate your nosepiece so that neither of the objectives is clicked into position. This is called the neutral position. Microscopes are to be stored with the lenses in the neutral position.

Summary Questions

1. Why should lens tissue be used to clean the lenses of the microscope?
2. How should a microscope be carried?
3. What is the function of the mirror?
4. How do objects appear to move when viewed under the microscope?
5. What happens to the field of light when changing from low power to high power?

Lesson 21 Preparing a Wet Mount

Laboratory Exercise

Aim: How can we prepare a wet mount?

Materials

compound microscope, slides, cover slips, lens tissue, mixed protozoa culture, petroleum jelly, toothpicks, medicine dropper, methyl cellulose, paper towelling, depression slide

Outcomes

Living things can be studied under the microscope.
The wet mount is a technique used for viewing living organisms.

Motivation

Display a jar containing a mixed protozoa culture. Tell the class that there are probably more organisms in the jar than there are at the local zoo. Challenge students to explain how these organisms may be examined.

Procedures

1. Tell the class that living microorganisms can be viewed and studied under the microscope. Explain that these organisms must be viewed in their natural (watery) environment.
2. Elicit the need for maintaining this watery environment on a microscope slide. Challenge students to describe how this might be done.
3. Display a depression slide and briefly review the method used for preparing this slide for viewing. Explain the role of the cover slip in using this technique. Discuss the advantages and disadvantages of this method. Explain that depression slides can be used for viewing larger organisms. A disadvantage of this technique is the thickness of the slide, especially under high power.
4. Introduce the concept of the wet mount as a technique for viewing living organisms. Demonstrate how petroleum jelly and a tooth pick may be used to prepare a well or reservoir for containing the liquid medium to be observed. Also demonstrate the proper method for placing the cover slip on the slide.
5. Explain that very often, organisms viewed using the wet mount are moving, sometimes rapidly. Elicit the need for slowing down these organisms. Show the class a bottle of

methyl cellulose. Describe its viscosity. Elicit that this substance can be used to slow down the movements of organisms viewed on a wet mount.

Summary Questions

1. What is a wet mount?
2. What is the importance of petroleum jelly in preparing a wet mount?
3. How may the movements of organisms on a wet mount be slowed down?
4. How is a cover slip used on a depression slide?

Lesson 21

Preparing a Wet Mount

Student Laboratory Worksheet

Name ______________________ Date __________ Section __________

Aim: How can we prepare a wet mount?

Materials

compound microscope, slides, cover slips, lens tissue, mixed protozoa culture, petroleum jelly, toothpicks, medicine dropper, methyl cellulose, paper towelling

Procedures

1. Carefully clean several slides and coverslips with lens tissue. Place these on a piece of paper towel.
2. Using the petroleum jelly and a toothpick, make a circle on the slide about the size of a dime. Do not get any of the petroleum jelly inside the circle. Carefully wipe away any excess petroleum jelly.
3. Using the medicine dropper, carefully place 2 drops of methyl cellulose in the center of the petroleum jelly circle. Rinse the dropper with water.

   a. What is the function of the methyl cellulose? __________

   ____
4. Using the medicine dropper, place 1 drop of mixed protozoa culture on the methyl cellulose drops (in the petroleum jelly circle). Gently add a cover slip.
5. Clean your microscope lenses and place the slide on the stage. Carefully scan the slide under low power until you locate an organism. Draw what you see in the space provided.

6. Rotate the high power objective into position. Draw what you see in the space provided.

7. Clean up and return all materials to their proper place.

Summary Questions

1. What is the function of the petroleum jelly in the preparation of a wet mount?
2. What is the function of methyl cellulose?

Lesson 22 Estimating Size With The Microscope

Laboratory Exercise

Aim: How can the microscope be used to estimate the size of an object?

Materials

compound microscope, transparent metric ruler with millimeter scale

Outcomes

The microscope field is the bright circle seen through the ocular when the microscope is properly adjusted.

The diameter of a microscope field can be estimated under low power using a transparent metric ruler.

The diameter under high power and oil immersion can be estimated from the low power field.

Procedures

1. Identify the bright circle of light seen under the microscope as the field of view.

2. Review the method for finding the total magnification under the microscope. Guide the students to the understanding that magnification can be calculated by multiplying the power of the ocular by the power of the objective lens.

   Illustrate this by placing the following examples on the board:

   a. for low power magnification

   Ocular X Low Power Objective = total magnification

   10X X 10X = 100X

   b. for high power magnification

   Ocular X High Power Objective = Total Magnification

   10X X 40X = 400X

3. Elicit that objects viewed under low power are magnified 100 times; objects viewed under high power are magnified 400 times.

4. Distribute the metric rulers. Have the students examine the millimeter markings. Emphasize the fact that the distance between any two consecutive millimeter lines is very short. Have the students recall that the millimeter is divided into 1000 units called micrometers. Thus, 1 micrometer equals .001 of a millimeter.

5. Elicit that objects viewed under the microscope are so small that they must be measured in micrometers.

6. Tell the students that the diameter of the low power field can be estimated. Explain that this can be done by using a transparent ruler. Once the diameter of the low power field has been estimated, the diameter of the high power and oil immersion fields can be estimated as well.

Summary Questions

1. How can the total magnification of a compound microscope be obtained?
2. Calculate the total magnification of an oil immersion system when the power of the ocular is 10X and the power of the oil immersion lens is 97X.
3. What is a micrometer?
4. What is the microscope field?

Lesson 22 Estimating Size With The Microscope

Student Laboratory Worksheet

Name ______________________ Date _________ Section _________

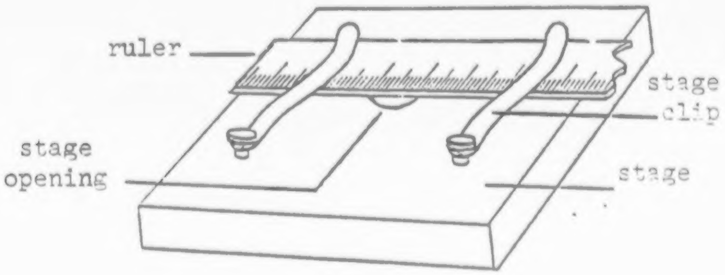
Aim: How can the microscope be used to estimate the size of an object?

Materials

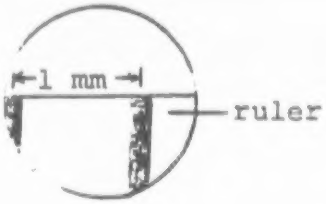
compound microscope, lens tissue, transparent metric ruler with millimeter scale, prepared slides of paramecium

Procedures

1. Prepare your microscope for low power viewing.
2. Place your transparent metric ruler across the widest part of the stage opening. Use the stage clips to hold the ruler in place.



3. Focus under low power. Slowly move the ruler so that 2 millimeter lines can be seen in the microscope field.



4. Estimate the width of the field as follows:
   a. Count the number of millimeters seen in the field.
   b. Estimate how much more than one millimeter the diameter of the field contains. Include the thickness of the lines.
   c. Add both of these numbers.

number of mm + estimation = width of field in mm

__________ + ________ = _________ mm

5. Convert your width of field from millimeters to micrometers. Remember, there are 1000 micrometers per millimeter. For example:

   width of field (mm) X 1000 = width of field in µm

   1.2 X 1000 = 1200 micrometers (µm)

   _________ X 1000 = _______ µm

6. Under high power magnification, the field size is 1/4 the size of the low power field; but the magnification is four times greater. Thus,

$$\frac{1.2 \text{ mm}}{4} = 0.3 \text{ mm}$$

$$0.3 \text{ mm} \times 1000 = 300 \text{ µm}$$

7. Place the prepared slide of paramecium on the microscope stage. Focus under low power.

   a. Estimate the length of the organism (in micrometers).

   ____

   b. Estimate the width of the organism (in micrometers).

   ____

Summary Questions

1. An organism measures approximately 0.8 mm in length under low power. How many micrometers long is the organism?
2. If this organism could be viewed under high power, how long, in micrometers, would it measure?
3. What is the field size under high power magnification as compared with low power magnification?

UNIT II

HEMATOLOGY

INTRODUCTION

The close physiological relationships and similarities among mammals are the key to the usefulness and applicability of this unit, which deals with hematology. While in this unit students investigate human hematology, the application of this area to the diseases of other mammalian species is understood. The transference and application to small animals of skills learned in the following exercises, which deal with humans, is then easily made. The time allotted to this unit is enough to allow students to sample a good variety of techniques, easily mastered by them and dramatic enough in their results to maintain interest at a high level.

Lesson 23 Composition of Blood

Aim: What is the composition of the blood?

Materials

container of citrated whole blood, student handout sheets illustrating the variety of blood cells

Outcomes

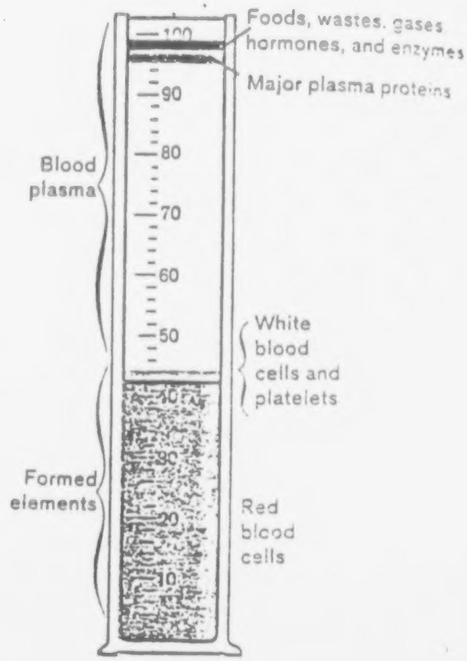
Blood is a liquid tissue
Blood consists of formed elements and plasma
The formed elements are red blood cells, white blood cells, and plasma
Plasma is the non-living, liquid part of the blood

Motivation

Tell the students that blood is often referred to as the "River of Life." Challenge them to explain the meaning of this statement.

Procedures

1. Develop the understanding that blood is a body tissue. Elicit that blood differs from many other body tissues in that it is a liquid.
2. Display a container of citrated whole blood. Elicit that whole blood consists of two main portions; a clear, straw-colored liquid or plasma, and the formed elements. Explain that the formed elements consist of red blood cells, white blood cells, and platelets.
3. On the board, develop that red blood cells make up approximately 43% by volume of the blood; white blood cells and platelets approximately 2% by volume; and plasma about 55% by volume.


Foods, wastes, gases hormones, and enzymes
Major plasma proteins
Blood plasma
White blood cells and platelets
Formed elements
Red blood cells
100
90
80
70
60
50
40
30
20
10

4. Distribute the student handout sheet. Identify and discuss each of the cells. Have the students record the structure and function for each in the space provided on the handout sheet.

   a. red blood cells (RBC) Identify the red blood cell as a biconcave disc which measures about 8.0 micrometers in diameter. Have students note the absence of a nucleus in mature forms of these cells. Develop the understanding that red cells are produced in the red marrow of most bones. Explain that red blood cells contain a red, iron-containing pigment called hemoglobin. Develop that hemoglobin is responsible for the ability of red blood cells to carry oxygen.

   b. white blood cells (WBC) White blood cells are colorless, and contain a nucleus; most are larger than red blood cells. Explain that white blood cells may be differentiated by their ability to accept stains.
   Lymphocytes: These cells contain a large nucleus surrounded by a small amount of cytoplasm. The diameter of lymphocytes is approximately equal to that of the red blood cells. Lymphocytes make up about 20-35 percent of all white blood cells. Evidence suggests that these cells are involved in antibody production.
   Monocytes: Monocytes are large, amoeba-like cells measuring up to 25 micrometers in diameter. These cells contain a large nucleus which is surrounded by much cytoplasm. Monocytes make up about 2-6 percent of the body's leukocytes. Monocytes are phagocytic. Their amoeboid body allows them to move freely through the capillary walls. As they move, they ingest bacteria and other foreign bodies.
   Neutrophils: Neutrophils have large nuclei which are segmented or divided into lobes. These cells measure about 12 micrometers in diameter. Neutrophils are the most abundant of the white blood cells, making up about 55 to 75 percent of these cells. Like monocytes, neutrophils are also phagocytic.
   Eosinophils and Basophils: These cells are about the size of neutrophils. Eosinophils make up about 1 to 3 percent of the leukocytes; basophils no more than 1 percent. These cells carry on some phagocytosis. Scientists are uncertain as to their other functions.

   c. Platelets Platelets are not cells. They are fragments of large cells in the red marrow which constantly shed small pieces into the blood. Platelets are very small, measuring about 2 micrometers in diameter. When bleeding occurs, platelets release a substance which begins the complex process of blood clotting.

d. Plasma Develop the understanding that plasma is the non-living, liquid portion of the blood. Its dominant component is water (90 percent). Plasma contains dissolved gases, salts, nutrients, wastes, and regulatory substances (hormones). Plasma also contains plasma proteins, albumin, and globulins. Included among the globulins are the antibodies that combat infectious diseases.

Summary Questions

1. What is the function of red blood cells?
2. How do leukocytes differ? How are they the same?
3. What is the function of platelets?
4. Describe plasma.
5. Why is blood often referred to as the "River of Life"?

Lesson 23

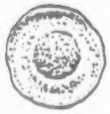
Composition of Blood

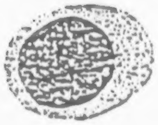
Types Of Blood Cells

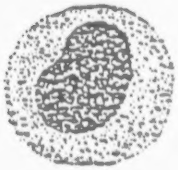
Name ______________________ Date __________ Section __________

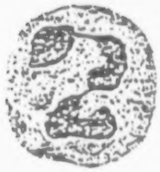
Aim: What is the composition of the blood?

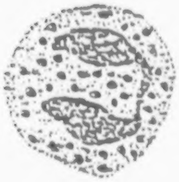
Identify and describe each of the following types of blood cells.

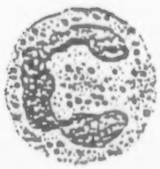












Lesson 24 Principles of Staining

Aim: Why are stains necessary for the microscopic study of blood?

Materials

variety of stains for display: Wright's stain, Lugol's iodine, methylene blue, hematoxylin-eosin, Gram stain, 2 large test tubes, sodium chloride solution, silver nitrate solution, two beakers, dialyzing membrane, string

Outcomes

The parts of cells and tissues are generally colorless and difficult to distinguish under the microscope.
Stains give color to various cell parts.
Simple stains dye cell parts different shades of one color.
Differential stains dye various cell parts different colors.

Motivation

Display two beakers of water, one containing a small piece of dialyzing membrane filled with water and sealed; the other containing dialyzing membrane filled with water and a vegetable dye (also sealed). Ask students to describe what is in each beaker.

Procedures

1. Explain that although both beakers contain a membrane filled with water, the membrane containing the vegetable dye was more easily seen.

2. Develop the understanding that cells consist mostly of water. Ask students what problems might arise when studying cells under the microscope. Elicit that many of the cell parts would be invisible.

3. Demonstrate one of the principles of staining as follows:

   Place a small amount of salt solution (NaCl) into a test tube ½ filled with silver nitrate ($AgNO_3$) solution. Have students observe what occurs.

   Place the following word formula on the board:

$$\begin{array}{c}\text{sodium}\\\text{chloride}\end{array} + \begin{array}{c}\text{silver}\\\text{nitrate}\end{array} \longrightarrow \begin{array}{c}\text{sodium}\\\text{nitrate}\end{array} + \begin{array}{c}\text{silver}\\\text{chloride}\end{array}\downarrow$$

   Define the term precipitate. Identify silver chloride as the precipitate formed in the above reaction. Explain that substances in cells often form colored precipitates with stains.

4. Explain that some stains color by adhering to cell parts. Others actually penetrate cell parts.

5. Refer to Lugol's iodine and methylene blue. Identify these as simple stains. Define simple stains as those which dye cell parts different shades of one color.

6. Refer to Wright's stain and hematoxylin-eosin. Identify these as differential stains. Explain that these stains dye various cell parts different colors.

7. Explain that most cells are killed by stains. Some stains, called vital stains, dye cells so that these may be studied alive.

8. Refer students to the worksheet on the composition of the blood. Explain that the various white blood cells can be identified and studied by their ability to accept a differential stain.

Summary Questions

1. What is a stain?
2. Why are stains used?
3. How do some stains work?
4. What is a vital stain?

Lesson 25 Preparing A Blood Smear

Laboratory Exercise

Aim: How is a blood smear prepared?

Materials

soap, sterile gauze pads, 70% alcohol, sterile lancet, microscope slides, prepared blood, pancake syrup (molasses), lens tissue, paper towel, medicine dropper

Outcomes

Finger puncture requires techniques which assure against infection and promote the free flow of blood.
A blood smear consists of a layer of blood cells one cell thick, spread across a glass slide.
Blood smears are necessary for the identification and count of formed elements.

Motivation

Ask students to explain how a blood smear of human or animal blood may be useful in the diagnosis and treatment of certain diseases.

Procedures

1. Demonstrate how a drop of blood is obtained through finger puncture. Students should not be used in this activity. The following steps should be observed:

   a. Wash the hands with soap and warm water.
   b. Wipe the top of the middle finger with a sterile gauze pad soaked with 70% alcohol.
   c. Dry the finger with a sterile gauze pad.
   d. Make the finger puncture using a sterile lancet.
   e. Wipe away the first drop of blood.
   f. Allow a second drop of blood to form.
   g. Apply this drop of blood to a slide.
   h. Blood flow can be stopped using direct pressure with a sterile gauze pad.

2. Demonstrate the proper method for smearing the blood across the slide. Tell the students that, in the laboratory part of this lesson, they will prepare an actual blood smear.

3. Distribute laboratory materials and student worksheets. Circulate among the students as they perform the required tasks.

Summary Questions

1. Why is alcohol used to swab the finger when making a finger puncture?
2. What is a blood smear?
3. What is the importance of a blood smear?

Optional Activity

Blood may be collected from small animals in a veterinary practice in a variety of ways. In dogs, blood can be taken by venipuncture from cephalic or jugular veins, using a needle and syringe. Small amounts of blood, for procedures such as hemoglobin and blood count determination, can be collected from small animals such as kittens and rabbits by shaving an ear and collecting from the external ear vein.

Lesson 25

Preparing A Blood Smear

Student Laboratory Worksheet

Name ____________________ Date __________ Section __________

Aim: How is a blood smear prepared?

Introduction

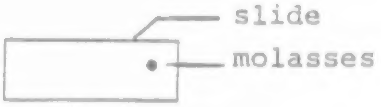
The preparation of a blood smear is an important laboratory procedure. Making a proper smear often requires much practice and patience. In this laboratory exercise, you will use syrup (molasses) to help you practice preparing a smear. When you have mastered the technique, you will prepare an actual blood smear.

Materials

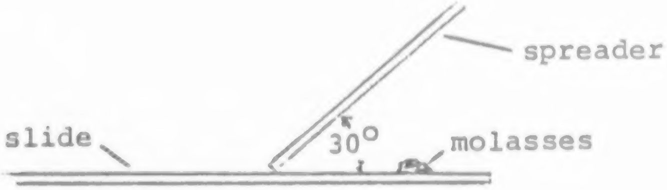
microscope slides, pancake syrup (molasses) prepared blood, lens tissue, paper towel, medicine dropper

Procedures

1. Clean several glass slides with lens tissue. Place the slide so that it is flat on the table.
2. Place a drop of molasses solution on the center of the slide, about 2 cm from one end, as shown.

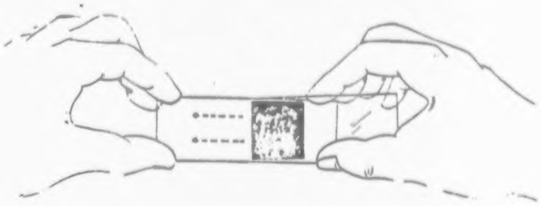


3. Use a second slide as a spreader. Place the edge of the spreader (at an angle of about 30°) on the center of the slide containing the molasses drop.



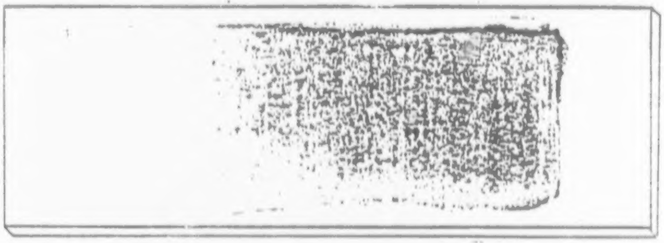
4. Move the spreader toward the molasses drop until it touches the drop. The molasses should spread across the slide edge.

5. Quickly push the spreader slide in the opposite direction. Use a smooth, gliding motion. Allow the slide to air-dry.

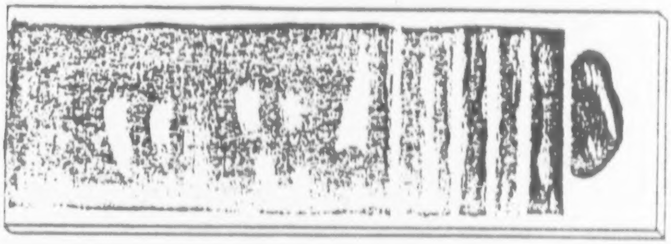


6. Repeat steps 1-5 until a smooth smear is obtained. When you are satisfied with your results, prepare a smear using prepared blood.

7. Compare your blood smear with the illustrations below. How do they compare?



Good Smear



Try Again

8. Label your slides and give them to your teacher for storage.

Lesson 26

Oil Immersion Techniques

Laboratory Exercise

Aim: How is the oil immersion lens used to examine blood slides?

Materials

oil immersion microscope, commercially prepared human blood slide, cedar (or other) immersion oil, commercially prepared slide of frog blood

Outcomes

The oil immersion microscope magnifies approximately 900X or more through a special, oil immersion objective.

Motivation

State that several types of diseases can be diagnosed through a careful microscopic examination of the blood. Challenge students to explain how blood cells may be studied. Elicit that high magnification is necessary for this.

Procedures

1. Display an oil immersion microscope. Identify the oil immersion objective and the magnification printed on it.

2. Demonstrate the proper technique for using the oil immersion lens. Explain that as magnification increases, light coming through the objective is spread and dimmed. State that immersion oil prevents loss of light so that viewing is possible even at very high magnifications.

3. Distribute student laboratory materials and laboratory worksheets. Instruct students to read directions carefully and to work slowly.

Summary Questions

1. Which type of cell is most numerous in human blood?
2. What differences do you observe between human and frog red blood cells?
3. How do the numbers of red blood cells and white blood cells in human blood compare?

Lesson 26 Oil Immersion Techniques

Student Laboratory Worksheet

Name ______________________ Date _________ Section _________

Aim: How is the oil immersion lens used to study blood slides?

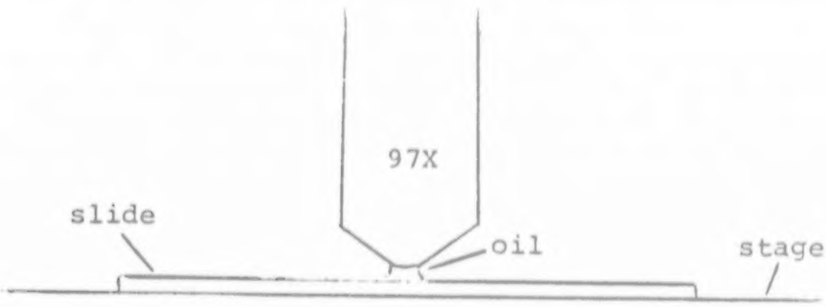
Materials

oil immersion microscope, commercially prepared human blood slide, immersion oil, commercially prepared slide of frog blood, lens tissue

Procedures

1. Prepare the microscope for viewing. Make certain that all lens surfaces are properly cleaned.
2. Place a slide of human blood on the microscope stage. Focus under low power, then under high power. Carefully select the field you will examine under oil immersion. Raise the objective approximately 2 centimeters.
3. Place a drop of immersion oil on the slide. Make certain that the oil is placed directly over the center of the opening in the stage.
4. Slowly rotate the oil immersion objective until it clicks into place.
5. Look from the side of the stage. Carefully lower the oil immersion lens until contact is made with the oil on the slide.

NOTE: The oil should cling to the objective lens and the surface of the slide in a continuous column. See illustration.



6. Use the fine adjustment knob to obtain a clear, sharp image of the blood cells.

7. In the spaces below, draw and label as many different blood cells as you can.

Human Blood Cells Under Oil Immersion

8. Raise the objective and remove the slide from the microscope.

9. Repeat steps 1-7 using the prepared slide of frog blood. Draw what you see in the space below. Label your drawing.

Frog Blood Cells Under Oil Immersion

Summary Questions

1. Which cells are most numerous in human blood?
2. How do human red blood cells and frog red blood cells differ?
3. Compare the human red blood cells and white blood cells as to numbers of each as well as comparative size.
4. How does the oil immersion lens help in the study of blood?

Lesson 27 Staining Blood Smears

Laboratory Exercise

Aim: How is Wright's stain used to make blood cells more visible?

Materials

oil immersion microscope, immersion oil, previously prepared blood smears, Wright's stain, wash bottle of distilled water, Canada balsam, staining tray

Outcomes

Wright's stain colors the formed elements of blood smears so that these can be differentiated from one another.

Wright's stain consists of different colored dyes which are attracted to different parts of the cell.

Different types of cells can be differentiated from one another because their parts differ in size, shape, and color of stain taken in.

Procedures

1. Introduce Wright's stain as one of the more often used of the differential stains. Explain that Wright's stain is able to color the various parts of cells differently. Elicit that this allows different cell types to be differentiated and thus studied.

2. Explain that Wright's stain is a solution containing two dyes; eosin (an acid stain), and methylene blue (a basic stain), dissolved in methyl alcohol.

3. Point out that some white blood cells are named for their ability to combine with certain dyes. For example, eosinophils are "acid lovers,' basophils are "base lovers.' Neutrophils appear to "prefer" a mixture of both.

4. Point out that contrast is essential for proper staining. To obtain a proper contrast, buffer solutions are often used. Explain that buffer solutions function to help maintain a proper pH (6.4-6.8). Distilled water is often used because of its neutral pH.

5. Tell the students that in the laboratory part of this lesson, they will stain their previously prepared blood smears and then examine these under the oil immersion microscope.

6. Demonstrate the method for staining with Wright's stain.

Summary Questions

1. What is the advantage of using stains on blood smears?
2. What do the words eosinophil, basophil, and neutrophil mean?
3. What is the importance of buffer solutions in staining?
4. What are the substances used in preparing Wright's stain?

Optional Activity

Prepare a permanent blood slide. Place a drop of Canada balsam on top of a blood smear. Add a cover slip and gently press into place. Allow the balsam to dry for about a week to ten days.

Lesson 27 Staining Blood Smears

Student Laboratory Worksheet

Name ____________________ Date __________ Section _________

Aim: How is Wright's stain used to make blood more visible?

Materials

previously prepared blood smears, staining tray, paper towels, Wright's stain, distilled water, medicine dropper, bibulous paper, lens tissue, oil immersion microscope, immersion oil

Procedures

1. Obtain your previously prepared blood smears and stain as follows:
   a. Place a slide (smear side up) on the rack of a staining tray.
   b. Drop Wright's stain onto the smear until the entire slide is fully covered (25-40 drops).
   c. Allow to stand for 1-2 minutes.
   d. Add 20 drops of distilled water. Distribute the drops evenly throughout the slide.
   e. Gently blow across the slide until a green metallic film appears.
   f. Wash the staining solution away by gently flooding the surface of the slide with distilled water.

2. Remove the slide from the rack. Make certain to handle the slide by its edges. Dry the bottom of the slide and drain remaining water by standing the slide so that a long edge rests on blotting paper. Allow to air-dry in this position.

3. Examine your prepared slide under oil immersion. Complete the following table based upon your observations.

Cell	Color of Nucleus	Color of Cytoplasm	Appearance of Nucleus	Appearance of Cytoplasm
Lymphocyte				
Monocyte				
Basophil				
Neutrophil				
Eosinophil				
Red Blood Cell				

4. Remove the slide from the microscope stage. Gently blot the oil from the slide using bibulous paper.

Summary Questions

1. Why must a prepared slide be handled by its edges?
2. What is the function of a buffer?
3. How do white blood cells differ?

Lesson 28 Differential Leukocyte Count

Laboratory Exercise

Aim: How do we determine the number of different types of white cells in a blood smear?

Materials

oil immersion microscope, immersion oil, previously stained blood smears

Outcomes

A differential white blood cell count establishes the approximate number of each type of white blood cell per one hundred cells.

Making an accurate differential count depends upon careful examination of a smear by a set, repeatable pattern.

Motivation

Challenge students to explain what leukemia and infectious mononucleosis have in common. Elicit that both are diseases of the blood in which there is an increase in the number of white blood cells. Ask how it might be possible to diagnose the presence of either of these diseases.

Procedures

1. Establish that the diagnosis of many blood diseases in people and small animals depends, in part, upon determining the approximate number of each type of white blood cell present.

2. With the aid of a prepared wall chart, discuss the characteristic properties of the various types of white blood cells. The following should be included:

   Lymphocyte: Large, dark blue nucleus, almost filling cell; small amount of light blue cytoplasm; diameter about that of a red blood cell.
   Monocyte: Blue-gray nucleus, slightly bent into crescent shape; cytoplasm light blue with granules; almost twice lymphocyte diameter.
   Neutrophil: Nucleus usually has three to five lobes, or less often a distinct "C"-shape; colored blue-purple; cytoplasm contains small, deep pink granules; diameter about half that of red blood cells.
   Basophil: Nucleus has several lobes; cytoplasm has large purple granules; diameter about equal to that of neutrophil.
   Eosinophil: Nucleus has several lobes; cytoplasm has many large red granules; diameter about equal to that of neutrophil.

3. Distribute student materials and laboratory worksheets. Supervise students as they make a differential count of their stained blood smears. Stress the importance of first focusing on a thin portion of the smear and on following a definite pattern.

   Explain that this pattern is necessary because, as a smear is prepared, large cells tend to concentrate at the edges of the slide, while smaller cells occupy the center. Following a pattern helps include both cell types (large and small).

Summary Questions

1. What is a differential white blood cell count?
2. Why is a differential count important?
3. How do the various types of white blood cells differ?
4. What precaution must be taken in making a differential count? Why is this important?

Lesson 28 Differential Leukocyte Count

Student Laboratory Worksheet

Name ______________________ Date _________ Section _________

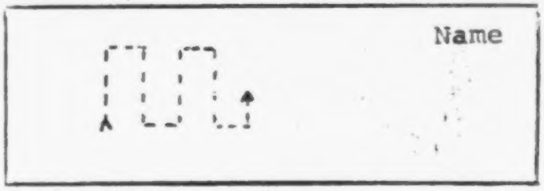
Aim: How do we determine the number of different types of white cells in a blood smear?

Materials

oil immersion microscope, immersion oil, lens tissue, stained blood smear

Procedures

1. Prepare your slide for viewing under oil immersion. Focus on the thin portion of the slide.
2. Use the illustration below as a suggested pattern for scanning. Count 100 consecutive white blood cells.



3. Keep an accurate tally of your count in the table below. Calculate and include the percentage for each type of cell. Remember, when you use 100 as your base for calculations, the actual number of cells counted is equal to the percentage.

White Blood Cell	Number of Cells	Percentage
Neutrophils		
Eosinophils		
Basophils		
Lymphocytes		
Monocytes		

Lesson 29 Major Human Blood Types

Aim: How do we explain the major human blood types?

Materials

chart on blood typing showing agglutinations

Outcomes

The major human blood types are A, B, AB, and O
Different blood types result from the presence or absence of specific proteins called agglutinogens, found on the cell membrane of red blood cells

Motivation

Ask students how many of them know their blood type. Pose the question, "What is blood type and why is it important?"

Procedures

1. Elicit the four major human blood groups; A, B, AB, and O.

2. Introduce the term agglutinogen. Explain that an agglutinogen is a special type of protein found on the cell membrane of human red blood cells. State that human blood groups are named for their agglutinogens.

3. Briefly discuss and develop the concept of antigen-antibody reactions. Explain that antigens are large molecules (usually proteins) which, when introduced into the body of an animal to which the antigen (protein) is foreign, will cause the formation of antibodies. Define an antibody as a substance produced by an animal which will combine with an antigen to neutralize or inactivate it.

4. Point out that agglutinogens can function as antigens when introduced into other people.

5. Explain that in most blood types, the plasma contains proteins called agglutinins. State that agglutinins are antibodies. Agglutinins act on incompatible agglutinogens by clumping (agglutinating) the red blood cells which carry them.

6. Elicit that this attempt by the body to protect itself by inactivating antigens can be fatal, since clumped masses may block vital blood vessels thus preventing the flow of blood.

7. Develop the following chart on the board. Have students suggest which antibodies may be present with the agglutinogen(s) for each major group.

Blood Group	Agglutinogens on the red blood cells	Agglutinins in the Plasma
A	A	Anti-B Serum
B	B	Anti-A Serum
AB	AB	none present
O	none present	A and B present

Indicate that the agglutinogens and agglutinins must be different if clumping is to be avoided.

Summary Questions

1. How are the major blood types named?
2. What are agglutinogens? Antigens? When can agglutinogens act as antigens?
3. What are agglutinins? Antibodies?
4. What are the agglutinins present in type O blood? Type AB?
5. What should be determined before a blood transfusion is given?

Optional Activities

Vertebrate animals other than humans also exhibit blood differences. For example, the A, B, AB, and O heritable groups have been shown to exist among the great apes, chimpanzees, orangutans, and gorillas. Blood groups are seen in dogs, cats, and other vertebrates as well. Challenge interested students to report on the details and applications of such knowledge, especially in research. Have students connect such research with training in small animal care.

Lesson 30 Blood Transfusions

Aim: Which blood types can be safely transfused?

Outcomes

In blood transfusions, the person from whom the blood is taken is called the donor.
The recipient is the person recieving the blood.
Persons with Type O blood are known as universal donors.
Persons with Type AB blood are known as universal recipients.

Motivation

Relate the experience of early experimenters who attempted human blood transfusions; some of their patients were helped, while others suddenly and inexplicably died. Ask the class to explain the probable cause of the sudden deaths.

Procedures

1. Elicit that death due to blockage of blood vessels to vital organs can result from the clumping of cells when the wrong type of blood is given in a transfusion.

2. Develop the understanding that, during a transfusion, the donor's blood mixes with the recipient's blood very slowly. For this reason, donor antibodies are dispersed and usually do not put recipient cells in danger of being clumped.

3. Contrast this with the fact that recipient's antibodies are not appreciably dispersed during transfusion and therefore will clump donor cells if they are not compatible.

4. Refer to the table of agglutinogens and agglutinins developed in the previous lesson. Point out that many transfusions could result in injury or death. Stress also that normal medical procedure is to match blood types for transfusion.

5. Develop a chart which illustrates which bloods can and cannot be safely transfused. Develop the understanding that the primary concern is that blood introduced into a patient must not contain red blood cells which the patient's blood can clump.

Blood Type	RECIPIENT BLOOD (plasma antibodies important)			
DONOR'S BLOOD (red cell antigems important)	A (anti-B)	B (anti-A)	AB (no anti-bodies)	O (anti-A anti-B)
A	+	-	+	-
B	-	+	+	-
AB	-	-	+	-
O	+	+	+	+

KEY

+ transfusion usually safe
- transfusion unsafe

6. From the above table, have the students identify the universal donor (Type O) and recipient (Type AB). Stress that whenever possible, physicians prefer to match donor and recipient bloods exactly.

Summary Questions

1. Why is there danger that the wrong kind of donor cells will clump during a transfusion?
2. Why is there less danger that the recipient's cells will clump?
3. Which are the universal donor and recipient blood types?

Lesson 31 Blood Typing

Laboratory Exercise

Aim: How can we type human blood?

Materials

samples of blood types (A, B, AB, and O), microscope slides, glass marking pencil, anti-A serum, anti-B serum, toothpicks, magnifying lens

Outcomes

Blood type is an inherited characteristic which remains unchanged throughout life.

Blood types that can be used in combination are said to be compatible; those that cannot combine are incompatible.

Agglutination takes place when incompatible blood types are mixed.

Motivation

Challenge students to explain the importance of identifying various blood types. Elicit that mixing incompatible blood types produces an antigen-antibody reaction which may result in death.

Procedures

1. Tell students that blood type is an inherited characteristic rather than something that develops during life. Once formed, it is present throughout life.

2. Refer to the agglutinogen-agglutinin concepts previously studied. Explain that blood can be typed by applying the principle of antigen-antibody reactions.

3. Develop the following concepts:

    a. A person with type A blood has a red blood cell protein designated as A.
    b. This person also has a plasma protein designated as b. This plasma protein acts against (clumps) type B blood. Thus, it is referred to as an anti-B factor. Serum containing this factor is referred to as anti-B serum. A person with type A blood has anti-B serum.

4. Develop the following concepts:

    a. A person with type B blood has a red blood cell protein designated as B.
    b. This person also has a plasma protein designated as a. This plasma protein acts against type A blood. Thus, it

is referred to as an anti-A factor. Serum containing this factor is referred to as anti-A serum. A person with type B blood has anti-A serum.

5. Develop the following concepts:
   a. A person with type AB blood has red blood cell proteins designated as A and B.
   b. There are no agglutinins present in the plasma. Since no agglutinins are present, a person with blood type AB can receive blood (universal recipient) from any other blood group. No clumping takes place.

6. Develop the following concepts:
   a. In a person with type O blood, no agglutinogens are are present.
   b. This person has plasma proteins designated as a and b (anti-A and anti-B factors). People with type O blood are considered universal donors since there are no agglutinogens against which agglutinins may react.

7. Develop the understanding that compatible blood types are those in which no agglutinogen-agglutinin reaction takes takes place.

8. Distribute student materials and laboratory worksheets. Circulate among the students as they perform their blood typing.

Summary Questions

1. Explain how the antigen-antibody principle can be used to identify blood types.
2. From what type blood is anti-A serum obtained? Anti-B serum?
3. Why is type AB blood considered to be the universal recipient?

Lesson 31 Blood Typing

Student Laboratory Worksheet

Name ____________________ Date ________ Section ________

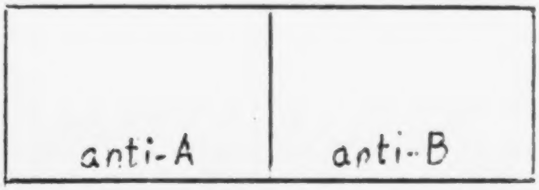
Aim: How can we type human blood?

Materials

samples of blood types (A, B, AB, and O), microscope slides, glass marking pencil, anti-A serum, anti-B serum, toothpicks, magnifying lens

Procedures

1. Divide the slide in half by drawing a line across the width, using a glass marking pencil.
2. Label the left side of the slide Anti-A; label the right side Anti-B.



3. Place a small drop of anti-A serum on the left side of the slide. Place a small drop of anti-B serum on the right side.
4. Place a drop of blood sample alongside each drop of serum.
5. Use a toothpick to mix the blood and serum on the left side. Mix for about 10 seconds. Discard the toothpick.
6. Use a second toothpick to mix the blood and serum on the right side. Mix for about 10 seconds. Discard the toothpick.
7. Do not disturb the slide for at least one minute, then examine.
8. Determine the blood type of the sample, using the table on the following page.

Reaction with:		
Anti-A serum	Anti-B serum	Blood Type
clumping	no clumping	A
no clumping	clumping	B
clumping	clumping	AB
no clumping	no clumping	O

9. Determine the blood type for the remaining samples.

Lesson 32 Rh Factor

Laboratory Exercise

Aim: How can Rh factor be determined?

Materials

Rh$^+$ and Rh$^-$ blood samples, microscope slides, glass marking pencil, anti-Rh serum, medicine dropper

Outcomes

The Rh factor is a potential antigen on the red blood cell of most people.

People having the Rh antigen are referred to as Rh$^+$ (Rh positive).

People lacking the Rh antigen are referred to as Rh$^-$ (Rh negative).

Blood may be identified as either Rh$^+$ or Rh$^-$ by testing for agglutination, using anti-Rh serum.

Motivation

Tell the students that determination of blood group alone is not all that should be considered before a transfusion is given. Explain that there is another potential antigen found on the red blood cell membrane. Identify this antigen as the Rh factor.

Procedures

1. Explain that approximately 85 percent of the people in the United States have the Rh factor, and identify the Rh factor as a potential antigen on the membrane of the red blood cell.

2. Elicit that people having the Rh factor are referred to as Rh positive (Rh$^+$). People who lack the Rh factor are referred to as Rh negative (Rh$^-$). Write these expressions on the board.

3. Guide students to the understanding that Rh$^+$ and Rh$^-$ people do not generally possess antibodies for the Rh antigen. However, if Rh$^+$ and Rh$^-$ blood is combined, the Rh negative person will produce antibodies that would destroy the Rh positive cells. Elicit the danger of this in transfusion.

4. Discuss the importance of Rh as it relates to pregnancy. Elicit the potential harm when a pregnant woman possesses Rh$^-$ blood, while the developing embryo may be Rh$^+$. How might the build-up of antibodies in the blood of the Rh$^-$ mother affect future embryos? Elicit the precautions that should be taken.

5. Demonstrate the method for determining Rh factor. Note that such reactions were first observed and studied by Karl Landsteiner and Alexander Weiner in the Rhesus monkey (hence "Rh").

Summary Questions

1. What is the Rh factor?
2. How may the Rh factor be important during pregnancy?
3. How is the Rh factor important during blood transfusions?

Optional Activity

Have students report on the frequency distribution of Rh^+ and Rh^- types around the world.

Lesson 32 Rh Factor

Student Laboratory Worksheet

Name ______________________ Date ________ Section ________

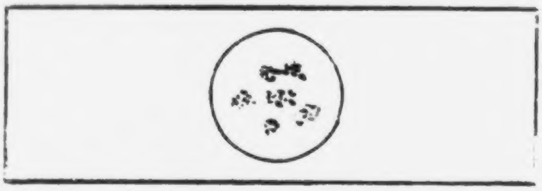
Aim: How can Rh factor be determined?

Materials

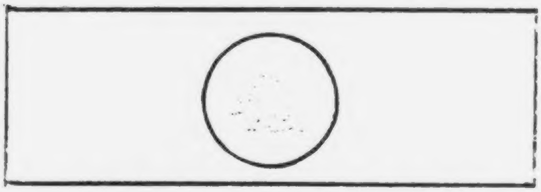
Rh^+ and Rh^- blood samples, microscope slides, glass marking pencil, anti-Rh serum, medicine dropper, microscope lamp

Procedures

1. Use the glass marking pencil to draw a circle (about the size of a dime) on a microscope slide.
2. Gently heat the slide over a microscope lamp. While the slide is still warm, place a drop of anti-Rh serum in the circle.
3. Using the medicine dropper, allow a drop of blood to fall freely onto the antiserum.
4. Hold the slide between the thumb and forefinger. Gently rock the slide back and forth for about 2 minutes.
5. Compare your slide to the illustrations below. Clumping indicates Rh^+, no clumping Rh^-.



Clumping Rh^+



No clumping Rh^-

6. Practice testing several other samples of blood.

7. Sample a. is ____________

Sample b. is ____________

Sample c. is ____________

Lesson 33 Nature And Functions Of Hemoglobin

Aim: What is the importance of hemoglobin?

Materials

beaker of laked blood (if available)

Outcomes

Hemoglobin is a red respiratory pigment found in the red blood cells of all vertebrates.
A hemoglobin molecule consists of a protein, globin, and four heme molecules, each containing an atom of iron.
Hemoglobin carries oxygen from the lungs to the tissues of the body.
Hemoglobin transports carbon dioxide from body tissues to the lungs.

Motivation

Elicit the composition of air at high altitudes. Explain that people living at high altitudes must compensate for the lesser amount of oxygen in the air at these altitudes. Challenge students to explain how this is possible.

Procedures

1. Discuss the Indians of the South American Andes. Explain that an examination of the blood of these people reveals a very high red blood cell and hemoglobin count. Elicit that this is a necessary adaptation for these people.

2. Define hemoglobin as a red respiratory pigment found in the red blood cells of all vertebrates. Tell the students that as much as 34 percent of human red blood cells consists of hemoglobin.

3. Discuss and develop the oxygen-carrying capacity of hemoglobin in terms of its structure. Explain that hemoglobin is a conjugated protein which consists of a protein, globin, and four heme molecules, each containing an atom of iron.

   Point out that oxygen attaches to the iron, forming the compound oxyhemoglobin. Show that hemoglobin forms a clear solution by displaying a beaker of laked blood.

4. Develop the importance of hemoglobin as an oxygen-carrying compound. Explain that many compounds readily combine with oxygen. The unique feature of hemoglobin is that this reaction is reversible. Thus, it readily gives up oxygen also. Under conditions of proper temperature, pH, and pressure, oxygen is picked up where the concentration is

highest (in the lungs), and released where the concentration is lowest (in the tissues).

5. Develop the understanding that about 40 percent of the carbon dioxide given off by cells during respiration combines with, and is transported by, hemoglobin to the lungs in the form of carbaminohemoglobin.

6. Elicit that the immediate danger stemming from the inhalation of automobile exhaust gases is that of carbon monoxide poisoning. Tell the class that one symptom of this condition is the development of a cherry-red skin color. Challenge them to suggest what might be the cause of this color (another form of hemoglobin resulting from combination with carbon monoxide). Point out that since this combination is difficult to break, carbon monoxide blocks further uptake of oxygen by hemoglobin molecules leading to cellular suffocation.

7. Ask the class what the effect of a diet deficient in iron is likely to be on the production of hemoglobin in the body. Lead them to the concept that this is only one cause of anemia, and that blood hemoglobin determination is a valuable tool in diagnosis of human and animal diseases.

Summary Questions

1. What is hemoglobin?
2. What property of hemoglobin enables it to carry oxygen to the tissues?
3. What other function does hemoglobin have?
4. How can the function of hemoglobin be blocked?

Lesson 34 Determination Of Blood Hemoglobin

Laboratory Exercise

Aim: How can we measure the concentration of hemoglobin in the blood?

Materials

blood samples, Tallquist conversion table, medicine droppers, 0.1 N HCl (1.0%), 25 ml pipette, Sahli-Adams hemometer, glass stirring rod, distilled water, 100 ml beaker, Sahli conversion chart, absorbent cotton

Outcomes

Blood hemoglobin concentration may be estimated through a color comparison, using a color chart.

In the Tallquist method, the color of a drop of blood on a special paper is compared to a color chart.

In the Sahli method, hemoglobin is acted upon by an acid and the solution is diluted to match a standard color.

Hemoglobin concentration may be calculated in grams per 100 ml of blood, or in percent.

Motivation

Challenge students to explain why doctors often examine the inner surface of the lower eyelid. Elicit that the color of the inner surface may indicate a type of anemia.

NOTE: The Tallquist and Sahli methods are best done with fresh blood obtained through a finger puncture, rather than citrated (venous) samples. The Tallquist method is simple to use but is ordinarily open to an error of about 20 percent or more.

Procedures

1. Elicit from the motivation that although examination of the inner surface of the eyelid may suggest anemia, more accurate methods for comparison against a standard are needed.

2. Demonstrate the Tallquist method of hemoglobin determination. Point out that while this method is the simplest to use, it is relatively inaccurate because of the difficulty in judging color matches. Students should understand that the use of venous blood will increase the degree of error since it is already dark in color. Refer to the conversion table on the student laboratory worksheet, and indicate that hemoglobin concentrations are expressed in grams per 100 ml of blood or in percent.

3. Demonstrate the Sahli method. Explain that acid hematin solution contains heme which has been altered by the action of acid. Stress the importance of adding distilled water to the acid hematin solution to achieve an exact color match with the comparison tube. Elicit that a source of error here, too, would lie in correctly judging the color match.

4. Inform students that modern methods of hemoglobin determination are still more accurate in that blood samples are examined electronically (by machine).

Summary Questions

1. Why is hemoglobin determination necessary?
2. Why is it so important to have a standard for comparison in estimating hemoglobin concentrations?
3. What advantage does electronic determination have over the Tallquist and Sahli methods?

Lesson 34 Determination Of Hemoglobin

Student Laboratory Worksheet

Name ______________________ Date __________ Section __________

Aim: How is the amount of hemoglobin in the blood estimated?

Materials

blood samples, Tallquist paper, Tallquist conversion table, medicine dropper

Procedures

1. Obtain a blood sample. Place a drop of blood from your sample on the surface of a sheet of Tallquist paper.
2. Allow the drop of blood to dry. Wait at least one minute.
3. Compare the blood spot on the Tallquist paper with the color chart. Move the paper in such a way that the blood spot appears through the hole in each color scale.
4. Take a reading when the two colors match. The reading you obtain is expressed as an approximate percent. Enter this reading here. ____________
5. Look at the Tallquist conversion table. It lists the conversions from percent to grams.

Tallquist Conversion Table

Gm.	1	2	3	4	5	6	7	8	9
%	6.3	12.6	18.9	25.2	31.5	37.8	44.1	50.4	56.7

Gm.	10	11	12	13	14	15	16	17	18
%	63.0	69.3	75.6	81.9	88.2	94.5	100.8	107.1	113.4

6. What is the approximate grams of hemoglobin? ____________
7. Repeat steps 1-6 using different blood samples. Estimate the amount of hemoglobin for each sample.

Summary Questions

1. What problems are there in using the Tallquist method of hemoglobin estimation?
2. Why is an accurate color comparison important?

Lesson 35 Measuring Hemoglobin Content

Student Laboratory Worksheet

Name ____________________ Date __________ Section __________

Aim: How can we accurately measure the hemoglobin content of blood?

Materials

blood samples, 0.1 N HCl (1.0%), 25 ml pipette, Sahli- Adams hemometer, medicine droppers, glass stirring rod, distilled water, 100 ml beaker, Sahli conversion chart, absorbent cotton

Procedures

1. Examine your hemometer tube. Notice that there are scales etched on opposite sides of the tube.
2. Hold the tube so that the yellow scale faces you. Use a medicine dropper and add 0.1 N HCl to the 2 gram mark. Remember the meniscus rule.
3. Using your pipette, draw 20 ml of blood from your blood sample.
4. Wipe the tip of the pipette with a piece of absorbent cotton.
5. Insert the pipette into the hemometer tube so the tip of the pipette is well below the surface of the acid.
6. Slowly discharge the blood into the acid by blowing gently.
7. Carefully rinse the pipette by drawing the mixture from the hemometer into the pipette and then gently blowing the mixture back into the tube. Repeat this several times. Try to avoid forming air bubbles.
3. Raise the pipette from the liquid and blow gently to empty.
9. Stir the blood-acid mixture with the stirring rod. Allow to stand for 10 minutes.
10. Place the hemometer tube into the hemometer.
11. Dilute the blood-acid mixture by adding distilled water, one drop at a time. Stir gently after each drop. Stop when the color of the mixture matches the color of the standard brown glass. It may be helpful to place a white card behind the hemometer.

12. Turn the hemometer so that the blue side is facing you. The level of the mixture (at the meniscus) is the concentration of hemoglobin in grams per 100 ml of blood.

13. Compare this reading with the conversion table to obtain the percent hemoglobin.

Sahli-Adams Conversion Table

Gm.	1	2	3	4	5	6	7	8	9
%	6.5	13.0	19.5	26.0	32.5	39.0	45.5	51.9	58.4

Gm.	10	11	12	13	14	15	16	17	18
%	64.9	71.4	77.9	84.4	90.9	97.4	103.9	110.4	116.9

Lesson 36 Blood Clotting Mechanism

Aim: How does blood clotting differ from blood clumping?

Materials

tube of clotted blood, cheesecloth, tube of citrated blood (oxylated)

Outcomes

Blood clotting consists of a series of complex chemical reactions.

The result of the clotting reaction is the formation of a network of fibers which traps blood cells.

The contracted fiber network plus the trapped cells form the clot.

Clumping occurs when red blood cells stick together as a result of antigen-antibody reactions.

Motivation

Ask students to describe what happens to blood when they cut themselves. Elicit that the bleeding stops as a result of the formation of a clot. Challenge students to explain how a clot forms.

Procedures

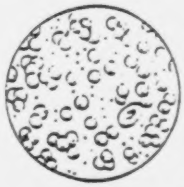
1. Have the students recall the blood typing activity. Elicit that clumping takes place when red blood cells stick together as a result of antigen-antibody reactions. Stress the fact that clumping involves only a sticking together of the red blood cells.

2. Display a tube of clotted blood. Ask several students to come up and examine the blood. Have them describe what they see to the rest of the class. Stress the physical consistency (viscosity) of the blood. Challenge students to explain what happened to the blood. Elicit that the blood is clotted (solidified). From their own personal experiences, elicit from the students that the formation of a clot is a natural and gradual process.

3. Develop the understanding that clotting invloves platelets and that it occurs as a series of complex chemical reactions. Reinforce the concept that, during clumping, the red blood cells stick together (clump) as a result of antigen-antibody reaction. Compare and contrast this with the fact that, during clotting, a series of chemical reactions result in an insoluble protein network (mesh) which traps blood cells and forms a clot.

4. Discuss and develop the clotting reaction as follows:

Blood Platelets —— break down when tissue damage occurs



↓

Thrombokinase (Thromboplastin) → an enzyme released by broken platelets

↓

Prothrombin → changed by thrombokinase in presence of Ca^{++}

↓

Thrombin

↓ acts upon

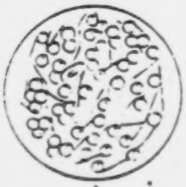
Fibrinogen (soluble)

↓

Fibrin → insoluble protein mesh

↓

Fibrin Net



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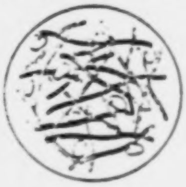
Trapped Red Blood Cells



5. State that the fibrin net enmeshes blood cells and forms a clot which stops bleeding. Use the piece of cheesecloth to demonstrate this mesh.

Summary Questions

1. What is the basic difference between clumped blood cells and a blood clot?
2. What enzyme is released by broken platelets?
3. What is fibrin? What does it form?

Optional Activities

1. Have students prepare a report on hemophilia, its problems, and recent developments toward the solution of these problems.
2. Have students research and report on blood types other than the ABO series.

Lesson 37 Bleeding Time And Coagulation Time

Aim: How do we determine the time required for blood to clot?

Materials

sterile lancets, 70% alcohol, sterile gauze, filter paper, 3 capillary tubes, watch with sweep second hand, microscope slides, dissecting needle

Outcomes

Bleeding is the result of ruptured blood vessels.
Bleeding time is the time it takes for bleeding to stop.
The normal stoppage of a flow of blood is referred to as hemostasis.
Coagulation time is the time required for blood to form a clot.

Motivation

Ask the class if any among them has ever been seriously cut. Elicit that the major concerns are stoppage of blood flow and avoiding infection. Explain that for small wounds, bleeding will usually stop within several minutes.

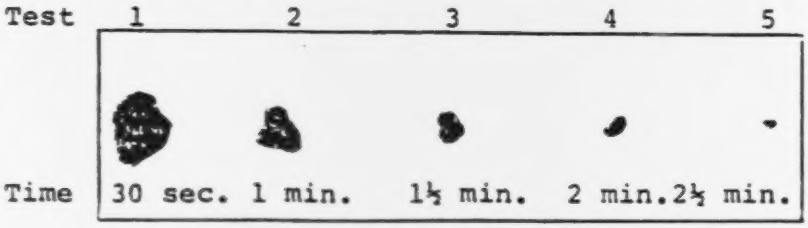
Procedures

1. Elicit that bleeding occurs when blood vessels are broken (ruptured).

2. Introduce the expression bleeding time. Define bleeding time as the amount of time it takes for bleeding to stop. Define hemostasis as the normal stoppage of blood flow. Explain that hemostasis results from contraction of blood vessel walls, as well as chemical reactions within the blood which cause the blood to solidify and "plug up" the wound.

3. Identify that the normal bleeding time for humans is from 1-3 minutes. Demonstrate how this is determined:

   a. Perform a finger puncture. Record the time.
   b. Remove blood drops at 30-second intervals by blotting gently on a piece of filter paper. Use a different spot for each drop. Record the time for each blotting.



4. Record the time when blood flow stops. Elicit that this is the bleeding time.

5. Display the piece of filter paper used for this test. You may want to use the board to amplify your findings.

6. Introduce the term coagulation time. Define coagulation time as the time required for blood to form a clot. Explain that two techniques may be used to determine coagulation time; the capillary tube method and the slide method. Demonstrate each.

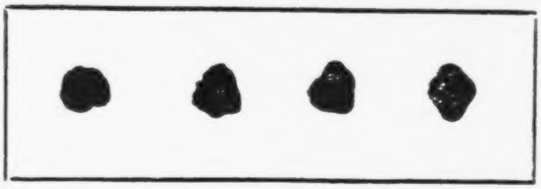
Capillary Tube Method

a. Perform a second finger puncture. Use a finger other than the one previously used.
b. Wipe away the first two drops of blood.
c. Touch the blood that continues to flow with the end of each of the three capillary tubes. Fill each tube about 3/4 full. Record the time of the filling of each tube and set these aside on a sheet of paper marked "1," "2," and "3."
d. After two minutes, break the first tube about 1/3 of the way along the blood column. Do not pull the pieces of tube apart.
e. Slowly separate the sections of tube. Look for the formation of a span of fibrin at the break.
f. After 1 minute, break the remaining section of this tube in a similar manner. Record the time.
g. The tube-breaking procedure should be continued with tubes 2 and 3, each being broken twice and each break at one-minute intervals.

Coagulation (clotting) time is the time interval elapsed from the filling with blood to the first appearance of a fibrin span in one of the capillary tubes.

Slide Method

a. Collect four drops of blood on a glass slide by touching the slide in four successive spots as shown.



b. Record the time of deposit of the drops. Wait 2 minutes.
c. Repeatedly (at 30-second intervals) draw the end of the dissecting needle through the drop of blood. Each drop may be tested more than once.

d. The catching of newly formed fibrin threads by the needle is evidence for clotting, and their time of first appearance should be recorded.

Coagulation time is the time elapsed from the placement of the drops of blood to the first adherence of fibrin threads to the needle.

Summary Questions

1. Define bleeding time.
2. How might the knowledge of bleeding time be useful in medicine?
3. Define hemostasis, fibrin span.
4. Describe a test for determining bleeding time.
5. What is coagulation time?
6. Describe 2 tests for determining coagulation time?

UNIT III

URINALYSIS

INTRODUCTION

Urinalysis has long been established as a routine laboratory procedure in the detection, diagnosis, and treatment of a broad spectrum of human and animal diseases. In this unit, the students are exposed to a sampling of the laboratory methods used in determining some of the physical and chemical properties of urine.

Lesson 38 The Need For Excretion

Aim: What happens to the wastes produced by cells?

Outcomes

All cells carry on metabolism.
During metabolic processes, waste materials are formed in the cells.
Waste materials must be removed from the body.
The excretory system removes metabolic wastes.

Motivation

Explain that during metabolic processes, small amounts of poisonous materials are produced by the cells of the body. If these materials are allowed to accumulate, they may interfere with cellular function. Elicit the need for the removal of these wastes.

Procedures

1. Define metabolism. Point out that metabolism is the sum total of all of the life functions. Indicate that all body cells carry on metabolism.

2. Challenge students to name some of the waste products formed during metabolism. Elicit that carbon dioxide and water are produced during respiration.

   Identify urea, salts, uric acid, altered bile pigments, and other nitrogen compounds as other metabolic wastes. Explain that as these wastes are produced in the cells, they pass into the blood.

3. Guide students to the understanding that many of the waste materials may interfere with cell functions if allowed to accumulate. Explain that if these materials are allowed to reach high levels of concentration in the blood, they can become harmful to cells. Elicit the need for the removal of these wastes.

4. Review the body systems. Have the students recall the function of each system. Elicit which of the body systems is responsible for the removal of cellular wastes in a liquid form.

   Identify the excretory system as the system which removes liquid wastes (dissolved substances) from the body.

5. Briefly review the function of the skin and lungs in the removal of liquid wastes.

6. Identify the kidneys as the major organs of the excretory system.

Summary Questions

1. Define metabolism.
2. What waste products are formed during metabolism?
3. How may these waste products be harmful?
4. How are cellular wastes removed from the body?

Lesson 39 Structure Of The Human Kidney

Aim: What are the parts of the kidney?

Materials

model of human torso, plaque of human excretory system, beef kidney model, chart of human kidney, chart of nephron structure

Outcomes

The kidneys are two bean-shaped organs located on the dorsal part of the abdominal cavity.

Each kidney is composed of about one million tiny structural units called nephrons.

The nephron consists of a glomerulus, capsule, tubules, and their capillaries.

Motivation

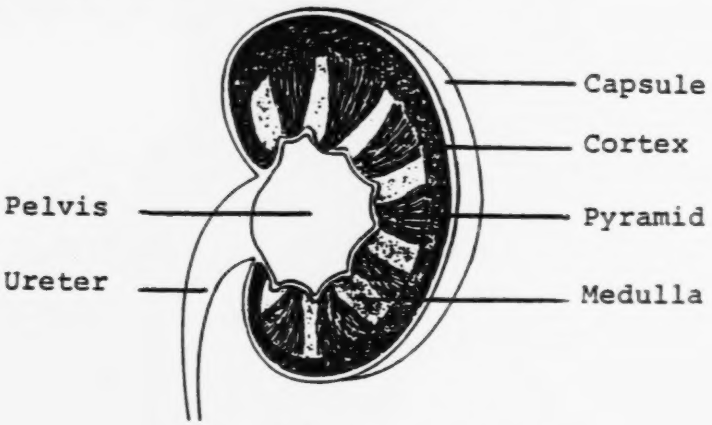
Challenge students to describe a kidney bean. Ask how the kidney bean gets its name. Elicit that a kidney bean is named for its shape and color, each of which closely resembles the mammalian kidney.

Procedures

1. Display the model of the human torso and the plaque of the human excretory system. Have the students identify the kidneys and their location. Point out that the kidneys are located on the dorsal part of the abdominal cavity.

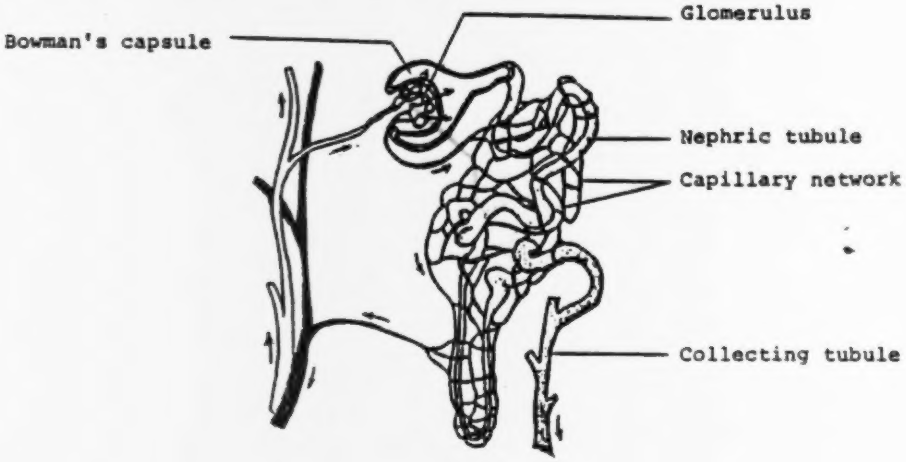
2. Display a dissectible longitudinal section of a beef kidney. Use charts and other available materials to reinforce the concept that the kidney consists of tissues which are arranged in a definite pattern.

3. Place the following illustration on the board, or reproduce for distribution. Label as shown.



Discuss and develop the gross anatomy of the kidney as viewed in longitudinal section. Stress the relationships between structures and their location.

4. Refer to the chart illustrating nephron structure. Identify the glomerulus, Bowman's capsule, nephric tubules, capillary network, and connecting tubule. Explain that the pyramids consist of collecting tubules and that the cortex is made up mostly of glomeruli and Bowman's capsule.



5. Guide students to a visual understanding of the location of the uterus, blood vessels, urinary bladder, and urethra in relation to each of the kidneys.

Summary Questions

1. Where are the kidneys located in the human body?
2. Name the basic unit of structure on the human kidney. What does this structure consist of?

Optional Activity

Report on kidney transplants.

Lesson 40 Functions Of The Human Kidney

Aim: How do the kidneys work?

Materials

charts on human excretory system, internal kidney structure, and nephron

Outcomes

The removal of waste products from an organism is called excretion.
Wastes are carried by the circulatory system to the kidneys, which function to (a) maintain blood composition, and (2) remove the wastes of cellular metabolism.
Wastes are removed in the nephrons by high pressure filtration and selective reabsorption.
The waste material that leaves the kidney tubules is called urine.

Motivation

Many people undergo dialysis while awaiting kidney transplants. How would you explain this in terms of the importance of the kidneys?

Procedure

1. Review the need for the removal of potentially harmful substances which are added to the blood as a result of cellular metabolism.

2. Inquire of students by what means the cellular wastes are collected from each cell and transported to the kidneys. Lead the class to the understanding that the circulatory system picks up the wastes from the cells and transports these to the kidneys.

3. Display the chart of the nephron, and have the class recall the structure of this kidney unit.

4. Make students aware of the fact that there are approximately one million nephrons in each kidney and that these are the functional units of the kidneys. Stress that each nephron is connected to the circulatory system.

5. Review the structure of the nephron. Explain that removal of wastes from the blood occurs in the glomerulus. In the glomerulus, high pressure filtration forces relatively small molecules dissolved in the blood (including water) out of the glomerulus and into Boman's capsule. From the capsule, the filtered materials move into the nephric

tubule, which is surrounded by a capillary network. Reabsorption of usable materials takes place in the cells of the nephric tubule. The usable materials then pass through the wall of the nephric tubule and into the capillary network where they are returned to the blood.

Identify the usable materials as water, dissolved nutrients, and mineral salts.

6. Guide students to the understanding that the waste material that leaves the kidney is urine.

Summary Questions

1. Why may kidneys be classified as regulators of internal environment?
2. What would happen if filtration were to occur in the nephron without reabsorption?
3. How is urine formed?

Optional Activities

1. Investigate and report on dialysis.
2. What are some of the problems related to kidney transplant?

Lesson 41 Kidney Dissection

Laboratory Exercise

Aim: What can we learn by dissecting a kidney?

Materials

fresh beef kidney, dissecting kit, dissecting tray, microscope, lens tissue, paper towelling, prepared slide of mammalian kidney, kidney chart, sheep kidney

Outcomes

The kidneys of such mammals as sheep and cattle are similar in structure and function to those of humans.

Microscopic examination of the kidneys reveals the structure and arrangement of the nephrons of which they are composed.

Motivation

Display both cow and sheep kidneys and ask what structures could be found in each. Ask whether the structures would be alike, and how this could be verified. Elicit that similarities and/or differences might well be revealed through a dissection of the kidney of a representative animal.

Procedures

1. Display the beef kidney and elicit its external features. Have students note its size, shape, color, and surface texture.
2. Demonstrate the method for dissecting the kidney. Include the orientation of the kidney in the dissecting tray, as well as the proper handling and use of the various dissecting tools.
3. Using low power magnification, set up a demonstration slide of a mammalian kidney. The nephron structure should be clearly discernible. Invite students to view the slide after they have completed their examination of the kidney.
4. Distribute student laboratory worksheets and materials. Circulate among the students as they perform their dissection. Encourage them to study the beef kidney and to compare it with the sheep kidney.

Summary Questions

1. Describe the structure of the sheep kidney as you observed it in your dissection.
2. How are beef and sheep kidneys similar? How do they differ?

3. Stand the kidney on edge so that the ureter is facing down (against the dissecting tray) and the broad curve of the kidney is up. If you have any questions, ask your teacher before you begin your dissection.

4. Using your scalpel, start at the broad curve and carefully slice downward. Divide the kidney into two equal halves.

5. Draw the inner surface of one of the sections. Label the capsule, cortex, pyramid, medulla, pelvis, and ureter. Refer to the wall chart if necessary.

6. Clean and dry your dissecting instruments. Return them to the kit for collection by your teacher.

7. Examine the prepared slide set up by your teacher. From the slide, draw and label one of the nephron units.

8. How does the nephron of the sheep kidney compare with the nephron of the human kidney?

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Lesson 41 **Kidney Dissection**

Student Laboratory Worksheet

Name ______________________ Date __________ Section ________

Aim: What can we learn by dissecting a kidney?

Materials

sheep kidney, dissecting tray, dissecting kit, paper towel, metric ruler, wall chart of kidney, chart of nephron structure

Procedure

1. Place the kidney in the dissecting tray. Examine the external features of the kidney.
   - a. Describe its shape and color. ______________________
   - b. Describe the texture of the kidney. ______________________
   - c. Use your metric ruler to measure the length, width, and thickness of the kidney.
     - Length: _______ cm
     - Width: _______ cm
     - Thickness: _______ cm
2. Draw the kidney in the space below. Consult the wall chart and label as many parts as you can.

Summary Questions

1. Describe the structure of the sheep kidney as you observed it in your dissection.
2. Describe the structure of the nephron in each of the kidneys you studied. How are these structures similar? How are they different?
3. How does your sheep kidney compare in size, shape, and texture with those of your classmates?

Lesson 42 Physical Properties of Urine

Laboratory Exercise

Aim: What are some physical properties of urine?

Materials

plugged test tubes, covered specimen cups, urine sample

Outcomes

Urine contains water, dissolved salts, and organic wastes.

The physical properties of urine may provide clues to diseases in the body, as well as conditions that may lead to damage of the organs of the urinary tract.

The results of laboratory tests on urine are valid only if the urine sample is collected and stored according to strict procedures.

Motivation

Ask students why a urine sample is routinely collected as part of a physical examination. Elicit that the properties of urine may be altered as a result of disease.

Procedures

1. Display the plugged test tubes and covered specimen cups. Identify these as containers used to store urine samples. Ask why these containers must remain sealed up to the time of actual examination of their contents. Elicit that for urine to be useful as a testing material, it must be free of contamination.

2. Challenge students to suggest what will happen to a freshly voided urine sample if it is allowed to remain uncovered at room temperature. Elicit that urine will deteriorate as a result of bacterial action.

3. Explain that urine kept for longer than one hour before analysis must be specially treated, or its chemical and cellular elements may deteriorate. Also, bacteria present in the urine would increase in number and have an adverse effect on test accuracy.

4. Guide students to the understanding that refrigeration (5° C) and chemical preservatives (toluene) help delay the deterioration of the sample. Relate this to their everyday experience with their own refrigerator. Ask students to read the wrapper of a loaf of bread and pick out related chemical preservatives and what tasks these perform.

5. Display a urine sample. Explain that the normal color of urine (amber or yellow) may be affected by a variety of components when disease is present. For example:

   a. A darker color may indicate concentrated urine.
   b. A pale color may indicate dilute urine.
   c. Red-brown color may indicate the presence of blood.
   d. Greenish color may indicate the presence of bile; or- when pale green- may indicate diabetes mellitus.
   e. Dark orange with pale yellow froth may indicate the presence of bile.

6. Point out that a freshly voided sample of normal urine has a characteristic aromatic odor. Students should understand that while the odor test for urine is not of special diagnostic importance, it may be used to reveal the presence of certain conditions. For example:

   a. A fruity odor (acetone) may indicate possible diabetes mellitus.
   b. Fecal odor may indicate bowel perforation.

7. Explain that freshly voided urine should be clear or transparent. Cloudy or turbid urine may indicate the presence of urinary tract infections, and may signal the need for further diagnostic tests.

Summary Questions

1. Why must urine be tested within an hour after collection?
2. Explain two ways of stabilizing urine that cannot be tested immediately.
3. What possible conditions may be indicated by urine with the following characteristics: (a) fruity odor, (b) fecal odor, (c) dark brown color.

Optional Activity

Have students report on methods used to collect urine from laboratory animals.

Lesson 42 Physical Properties of Urine

Student Laboratory Worksheet

Name ____________________ Date __________ Section ________

Aim: What are some physical properties of urine?

Materials

fresh urine samples, test tubes, test tube racks, 24-hour urine sample stabilized with toluene or other preservative, refrigerated sample, 24-hour sample (allowed to stand at room temperature)

Procedures

1. Examine a sample of freshly voided urine. Determine the characteristics of the sample and enter these on the table below.

Characteristic	Variation	Check Findings	Presumptive Conclusion N=Normal A=Abnormal
Color	colorless		
	amber		
	red		
	brown		
	smoky		
	orange		
	frothy when shaken		
	pale green		
	other		
Odor	fruity		
	spicy		
	fecal		
Transparency	clear		
	cloudy		
	smoky		

2. Examine the other samples provided by your teacher. Enter your observations below.

Sample Type	Color	Odor	Transparency
Refrigerated urine sample			
Toluene-stabilized sample			
24-hour at room temperature			

Summary Questions

1. How do the samples of urine used in procedure 2 differ?
2. How can you account for these differences?
3. Describe the normal color, odor, and transparency of urine.

Lesson 43 Specific Gravity of Urine

Laboratory Exercise

Aim: How can the specific gravity of urine be determined?

Materials

hydrometer, urinometer, 3-500 ml graduated cylinders, 250 ml saturated salt solution, 250 ml alcohol, urine sample

Outcomes

The specific gravity of any substance is equal to the weight of a given volume of that substance divided by the weight of an equal volume of water.

The specific gravity of water is (expressed as) 1.

The specific gravity of liquids may be equal to, less than, or more than the specific gravity of water.

Hydrometers are devices designed to determine the specific gravity of liquids.

The urinometer is a hydrometer specially designed to determine the specific gravity of urine.

Motivation

Challenge students to account for the fact that it is difficult to sink in the Great Salt Lake. Elicit that the concentration of salt dissolved in the water is responsible for keeping a body afloat.

Procedures

1. Explain that the amount of salt dissolved in water is related to the buoyant properties of the water. State that the buoyant property of urine may be used to determine the presence of disease conditions in the body.

2. Have students recall the lesson on density. Place the formula for density on the board. Elicit that density is the mass (weight) of a unit volume of a substance.

   Elicit that density is determined by dividing the mass (weight) of a substance by its volume.

3. Guide students to the understanding that the density of a substance, compared to a standard, is referred to as specific gravity. For liquids, the standard used is water. State that the specific gravity of water is 1.

   The specific gravity of liquids or solids is obtained by dividing the weight of a given volume of the substance by the weight of an equal volume of water.

$$\text{Specific gravity} = \frac{\text{weight of a volume of a liquid or solid}}{\text{weight of equal volume of water}}$$

4. Display and demonstrate the use of the hydrometer as follows. Fill 3-500 ml graduated cylinders ½ full with salt water, tap water, and alcohol respectively. Show that the hydrometer floats in these liquids and explain that the depth to which the hydrometer sinks depends upon the density of the liquid being tested.

   Establish that the more dense the liquid, the higher the hydrometer floats, and the lower the specific gravity of the substance tested.

   Remind students of the meniscus rule. Point out that to obtain the specific gravity, you read the number on the hydrometer touched by the bottom of the meniscus. From the above experiment, students should note that the specific gravity of a substance may be equal to, less than, or more than the specific gravity of water.

5. Display and demonstrate the use of the urinometer. Explain that the urinometer is a hydrometer specially designed to determine the specific gravity of urine.

   Explain that the normal range of specific gravity for urine is 1.005 to 1.030. State that first morning specimens are generally 1.020+.

Summary Questions

1. Define specific gravity.
2. How does specific gravity differ from density?
3. How does the specific gravity of alcohol compare with that of water?

Optional Activity

Prepare a report on human diseases which relate to a urinometer reading of lower than normal specific gravity; higher than normal.

Lesson 43 Specific Gravity of Urine

Student Laboratory Worksheet

Name ______________________________ Date __________ Section __________

Aim: How can the specific gravity of urine be determined?

Materials

urinometer, distilled water, known NaCl solution (sp. gr. 1.025), several salt solutions of unknown specific gravity, hydrometer, student urine samples from morning and previous afternoon

Procedures

1. Use the urinometer to determine the specific gravity of distilled water. If the urinometer reads above 1, the difference must be subtracted from other readings made. If it reads lower than 1, the difference should be added to other readings.

   Confirm your readings by checking the specific gravity of the known salt solution (sp. gr. 1.025). Enter your results in the table below.

Distilled Water	1.025 NaCl	NaCl #1 unknown	NaCl #2 unknown	Urine Samples AM	PM

2. Use the hydrometer to determine the specific gravity of the unknown salt solutions. Thoroughly rinse the hydrometer with water after each use. Record your results in the table.

3. Using the urinometer, carefully determine the specific gravity of your 2 urine samples (AM and PM). Rinse thoroughly between each measurement. Enter your results.

Summary Questions

1. In using either the hydrometer or urinometer, why is it important to rinse the instrument between measurements?
2. What differences occur in the specific gravity readings of AM and PM urine samples? How can you explain this?

Lesson 44 Urinary Sediments

Laboratory Exercise

Aim: What sediments can be found in urine?

Materials

urine samples, centrifuge, medicine droppers, microscope slides, lens tissue, cover slips, compound microscope, penlight or high intensity lamp

Outcomes

Urine contains suspended particles which can be separated out by centrifugation.

The substances which make up urinary sediments can provide useful clues to the state of health.

Motivation

Ask students if they have ever heard of or seen kidney stones. Challenge students to suggest the composition of these stones.

Procedures

1. Refer to the kidney stones previously discussed. Develop the idea that solid materials may be suspended in urine. Explain that some of these substances are in the form of crystals which may enlarge in the kidney to form actual stone-like masses. These stone-like masses are referred to as kidney stones.

2. Darken the classroom. Use a penlight or high intensity lamp to demonstrate the Tyndall effect in urine. Guide students to the understanding that the light beam is visible because light is reflected off small particles suspended in the urine.

3. Elicit that identification of such particles requires microscopic examination. Elicit further that centrifugation will concentrate these particles for study.

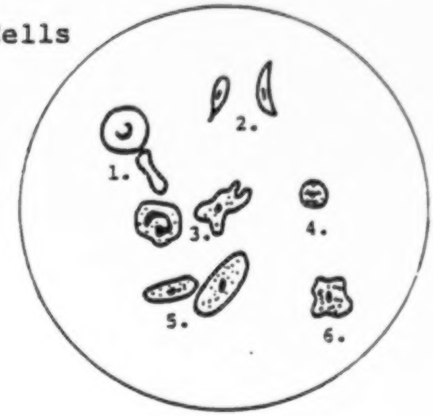
4. Spin down several samples of urine in a centrifuge for 3 to 5 minutes. Give the students one drop each of the sediment on a clean glass slide, and have them cover the sample with a cover slip.

5. Encourage students to examine their slides under low and high power. Have them draw their observations in the spaces provided on the student laboratory sheets.

The following is suggested as a guide to identification.

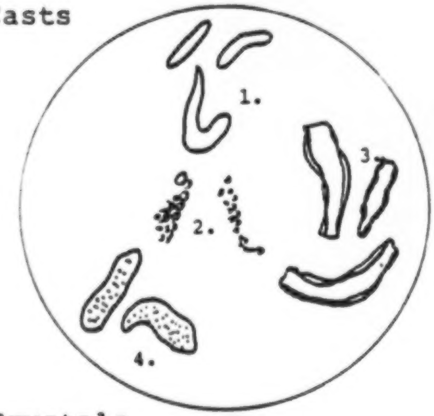
Urinary Sediments

Cells



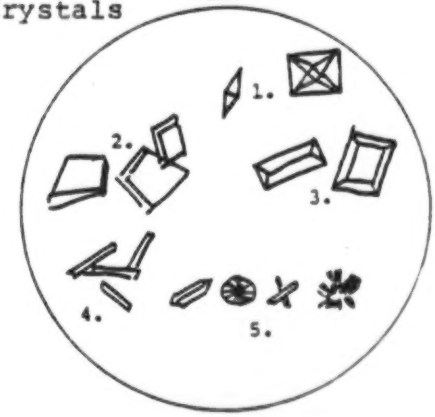
1. Red blood cell
2. Cells from ureter
3. White blood cells
4. Renal cell
5. Renal cell
6. Epithelial cell

Casts



1. Hyaline casts
2. Fatty casts
3. Waxy casts
4. Granular casts

Crystals



1. Calcium oxylate
2. Uric acid
3. Triple phosphate
4. Dicalcium phosphate
5. Calcium carbonate

6. Allow students sufficient time to examine the urinary sediments and prepare drawings of the most common types found. Emphasize that most urinary sediments are quite normally present, but that an abundance of certain types of sediment may be a clue to possible disorders.

   Normal urine may contain small numbers of the following sediments:
   - one or two red blood cells in a high power field
   - one or two leukocytes
   - several epithelial cells
   - an occasional hyaline cast (a protein cast of a tubule
   - small crystals (especially as urine cools)

Summary Questions

1. What does a beam of light disclose about urine?
2. What types of sediments may be observed in normal urine?
3. How important is the examination of urinary sediments in determining the state of health?

Lesson 44 Urinary Sediments

Student Laboratory Worksheet

Name ____________________________ Date __________ Section __________

Aim: What sediments can be found in urine?

Materials

urinary sediment, microscope slide, cover slip, microscope

Procedures

1. Obtain a sample of urinary sediment on a microscope slide. Add a cover slip and examine the slide under low power. Draw what you see in the space below.

2. Switch to high power. Draw as many kinds of sediments as you can.

Lesson 45 Urine pH

Laboratory Exercise

Aim: How can we determine the pH of urine?

Materials

nitrazine paper, hydrion paper, litmus paper (red, blue, neutral), prepared solutions (pH 5,6,7,8), pH meter (if available), urine samples (early AM and early PM)

Outcomes

The normal pH range of urine is from 4.5 to about 8.0 (average pH= 6.0).

The pH of urine varies according to time sample is taken, degree of exertion, and other factors.

The pH of urine may be determined using a variety of indicators.

pH tests may reveal the presence of substances in urine which should not normally be present.

Procedures

1. Have the students recall that the neutral point on the pH scale is 7.0, and that a pH of less than 7 would indicate an acid condition while readings above would be alkaline (basic).

   Tell the class that the average pH of urine is 6.0 (acid).

2. Guide students to the understanding that an increase in respiration rate (faster breathing) increases the carbon dioxide content of the blood. Explain that this, in turn, increases the acid level of the urine. Resting (as during sleep) would yield a lower acid reading (higher pH).

3. Discuss and develop those factors which may have a direct bearing on urine pH. Include such factors as medication, emotional state, fatigue, loss of ions due to water excretion, and diet.

4. Demonstrate the action of nitrazine paper on prepared aliquots of water of pH 5, 6, 7, and 8. Show the color change and obtain a reading by comparing with standardized color chart on nitrazine container. If available, confirm through use of pH meter. Test the other urine samples and record the readings on the board.

5. Explain that the paper indicators have been impregnated with chemical indicators (hydrion or nitrazine paper) which change color depending upon the pH of the substance tested.

Show that the spectrum of colors in these tests ranges from orange to green to blue to indicate pH readings from 5 through 9.

6. Point out that while the tests may indicate the presence of abnormal substances, other tests may be required in order to determine what these substances are and to what degree these are present.

Summary Questions

1. What information may be obtained by using pH indicators on urine?
2. What are the limitations of pH in identifying abnormal conditions?
3. What color range may be seen in a test with nitrazine paper? What does each color indicate?

Optional Activity

Assign student reports on the urine pH range normally found in small animals kept as pets or used in research. For example, the normal urine pH range for dogs and cats is 4.5 to 7.5.

Lesson 45 Urine pH

Student Laboratory Worksheet

Name ______________________ Date __________ Section ________

Aim: How can we determine the pH of urine?

Materials

tea samples (of unknown ph), student supplied urine, litmus paper (red, blue, neutral), nitrazine paper, hydrion paper

Procedures

1. Dip the strips of indicator paper (one at a time) into the urine sample. Enter your pH reading in the table below. Repeat for each of the unknowns.

Substance	Blue Litmus	Red Litmus	Neutral Litmus	Nitrazine Paper	Hydrion Paper	Reading
Urine sample						
Unknown #__						
Unknown #__						
Unknown #__						
Unknown #__						

Summary Question

Explain why hydrion or nitrazine paper is superior to litmus paper in determining pH.

Lesson 46 Testing Urine For Glucose And Albumin

Laboratory Exercise

Aim: How can urine be tested for glucose and albumin?

Materials

Benedict's solution, 500 ml beaker, electric hot plate, test tubes, medicine dropper, Clinitest tablets, Albustix, 10 ml graduated cylinder, glucose-tea solution, tea containing uncooked egg white, plain tea

Outcomes

Tests can be used to determine the presence of glucose and albumin in the urine.
The presence of glucose in the urine may indicate diabetes.
The presence of albumin in the urine may indicate kidney damage.

Motivation

Ask what measures are taken by diabetics to ensure that they are taking the proper amount of insulin each day. Elicit that diabetics must test their urine to be certain there is no glucose in it.

Procedures

1. Lead the class to the understanding that in diabetes there is excessive glucose in the blood. Explain that glucose is excreted into the urine when the nephric tubules are unable to reabsorb the excess back into the blood. Emphasize that after a meal heavy with starches and sweets, a normal person may have glucose in his or her blood.

2. Explain that albumin is one of the proteins in the blood plasma, but that it can leak through damaged glomeruli into the urine. Albumin can also appear in the urine of some individuals who are normal.

3. Demonstrate the detection of glucose in a glucose-tea solution by performing a Benedict's test, using a beaker of water boiled on a hot plate. Display the result.

   Test another tube of the same solution with a Clinitest tablet. Have a student interpret the result using the Clinitest color chart.

4. Use Albustix to test for the presence of albumin in the tea-egg white mixture. Again call on a student to verify the result.

Summary Questions

1. Why do we test for glucose and albumin in the urine?
2. Why must other tests be performed if either glucose or albumin is detected in the urine?
3. Of the three test methods used, which is the most convenient? Why?

Lesson 46 Testing Urine For Glucose And Albumin

Student Laboratory Worksheet

Name ______________________ Date __________ Section __________

Aim: How can urine be tested for glucose and albumin?

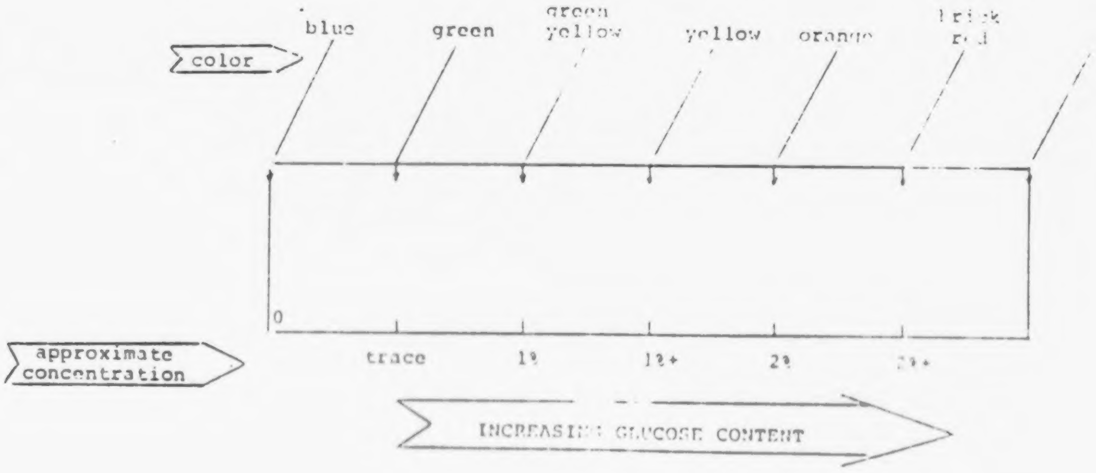
Materials

3 test tubes containing 10 drops of tea-glucose mixtures (1%, 2%, 2+% respectively), test tube rack, Benedict's solution, Clinistix, Bumintest tablets, hot plate, test tube clamp, 500 ml beaker, medicine dropper, 10 ml graduated cylinder, urine sample, test tube containing albumin-tea mixture, plain tea

Procedures

1. Add 5 ml of Benedict's solution to each of the 3 test tubes containing the tea-glucose solution.
2. Place the test tubes into a water bath on the hot plate. Boil for 3 minutes.

Allow to cool. Compare your results with the following chart. Enter these results in the table.


color
blue
green
green yellow
yellow
orange
brick red
0
approximate concentration
trace
1%
1%+
2%
2%+
INCREASING GLUCOSE CONTENT

	Tube #1	Tube #2	Tube #3	Albumin-Tea	Tea	Urine
Benedict's test						
Clinitest sticks (use chart)						
Bumintest tablet test						

3. Repeat for urine sample.

    a. Add 5 ml of Benedict's solution to 10 drops of urine in a test tube.
    b. Boil the mixture for 3 minutes in the water bath.
    c. Allow to cool.
    d. Compare color in test tube with chart.
    e. Enter your results in the table.

4. Confirm the Benedict's test results by using commercially prepared tablets or sticks (Clinitest tablets or Clinitest sticks).

    Urine should be mixed with water in a test tube in the proportion of 1 part urine to 2 parts water.

    a. Drop tablet into the urine-water mixture.
    b. Shake test tube. After 15 seconds, compare color with standardized color chart.
    c. Record your results.

5. Test the 2 tubes of tea. (Be aware that only one of the tubes contains tea and albumin). Determine which contains the albumin. Use the following procedure.

    a. Dissolve 3 Bumintest tablets in 30 ml of water.
    b. Into each of 2 test tubes, place 10 drops of the Bumintest solution.
    c. Add 10 drops of one of the tea mixtures to one of the test tubes. Add 10 drops of the remaining tea mixture to the other test tube.
    d. Examine for precipitate. Albumin is shown to be present if the mixture turns cloudy.
    e. Which test tube contains the albumin-tea mixture? Record your results.

Summary Questions

1. What test is performed using Clinitest sticks? How are the readings obtained?
2. Why are Bumintest tablets used?

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